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- PCB: 107 x 61mm

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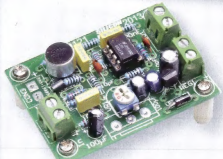

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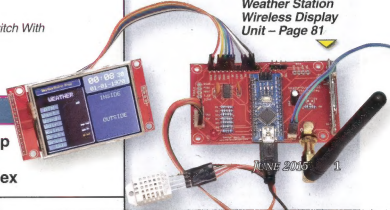

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Kevin Poulter
Dave Thompson

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Editorial office:
Unit 1, 234 Harbord Rd,
Brookvale, NSW 2100.

Postal address: PO Box 139,
Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

E-mail: silicon@siliconchip.com.au

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Publisher's Letter

Anti-islanding in grid-tied inverters is a big drawback

In the past, I have touched on the frustration of home-owners with solar panel installations who have no electricity during blackouts. They have this wonderful shiny panel installation which is prevented from generating power during black-outs by the "anti-islanding" feature of grid-tied inverters! This disadvantage was greatly magnified for many people in the aftermath of the severe weather in Sydney at the end of April.

Many thousands of people were without power for more than a week. Just imagine that: no power at all for a whole week – nothing for light, cooking, heating, computers, TV and other entertainment or cordless phones – you could not even charge your mobile phone! And this was in Sydney suburbs, not somewhere out in the sticks!

No-one was to blame for this situation as the storms downed many thousands of trees and the electricity linesmen were flat out reconnecting whole districts. Even as I write, the clean-up of felled trees is still going on and is likely to continue for another month or so.

Now we all know why this "anti-islanding" feature is incorporated into grid-tied inverters. It is there to protect linesmen who may be working on the system when there is a power outage. On the face of it, this is a good idea. But is it really necessary to also prevent the home-owner from having any electricity at all when there is a blackout? There are other ways of protecting linesmen.

The most obvious method would be to use the anti-islanding feature of the inverter to switch a contactor, so that the home-owner's system was disconnected from the grid but still leave the inverter itself to generate power. Sure, the home-owner would not get any benefit from feeding power into the grid but at least he (or she) would still have power while the Sun was shining. While there would still be no power available at night, most home-owners would be happy to work around this, knowing that food in their refrigerators was not going to spoil and many other power-using tasks such as clothes washing could be done during the day.

No doubt some people would argue that relying on a contactor to isolate the home-owner's system could be a recipe for a fatality. But surely a contactor could be arranged to "fail-safe" so that if it did not work, the system would be isolated anyway. I am sure that it would possible to arrange for redundancy in the monitoring and switching to make sure it was always safe and reliable. Of course, it would be necessary for the grid-tied inverter to still be able to monitor for the presence of power on the grid, so that the system would automatically switch back when grid power was restored.

If you concede that this idea has merit, then it is only a small step to allow solar systems which are grid-connected (no longer "grid-tied") to have battery storage so that home-owners can generate their own power during blackouts at night. The release of the Tesla PowerWall lithium battery system (see article on page 25 in this issue) makes this a practical scheme.

The solar panels would charge the PowerWall during hours of sunlight and feed the excess power into the grid. Then if there is blackout, the system automatically isolates itself from the grid and the home-owner can enjoy electricity as normal. The PowerWall would also have the benefit of smoothing the peaks in electricity demand from the grid, as it could supply at least some power after the Sun goes down.

Of course, the Tesla PowerWall might also persuade some electricity customers to disconnect themselves entirely from the grid and thereby avoid paying daily service charges.

Leo Simpson

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Disagreement with topics of Publisher's Letters

I would like to again take issue with your April 2015 editorial (Publisher's Letter). As before, I find the subject covered here has little to do with the magazine's content as suggested by the front page. It is as if the author of this item is simply using the magazine as a platform to air his personal opinions. This seems somewhat inappropriate.

Regarding the subject in the Publisher's Letter, when I studied technical subjects at TAFE back in the 1960s we were often told we could assume the planet was infinitely large and could take whatever you threw at it. But this is wrong. Modern technology has already used much of the planet's supply of rare earth metals to a point that they are now "rare". Air-conditioning has not always been beneficial; it was the source of a new illness, namely, Legionnaires' Disease.

I have spent many years working in technical areas, including broadcasting, and have become very concerned about the introduction and use of technologies simply because you can and not because they fill an existing need. Mobile phones, for example, generate their own uses often based on the expectations of others. I don't own one and yet am quite able to survive; why can't others? In the end the Earth's resources are finite and wearing "rose-coloured glasses", no matter how strong, will not change that.

Graeme Clinch,
Willoughby, NSW.

Comment: rare earths are still not actually rare. It is true that mining rare earths may be more expensive in the future but we are not going to run out. Legionnaires Disease occurs in poorly maintained air-conditioning systems with evaporative cooling towers. It is not a new illness, created by air-conditioning. It is simply yet another variant of bacterial pneumonia.

Rose-tinted glasses are ubiquitous

Unusually, I found myself agreeing with the Publisher's comments on the maintenance implications of roof-top solar in the May 2015 issue. I paused at the statement that DC is more dangerous than AC, since this is a contentious issue.

However, it was his advice that solar advocates remove their rose-tinted glasses that completely bewildered me. I know of no one who more proudly wears rose-tinted glasses than the Publisher. The previous month's editorial in the April issue was a classic example. His views on nuclear energy and the benign effects of climate change are just two examples.

Nothing would suit me better than the Publisher's optimistic views of the future playing out but surely prudence demands that we all remove our rose-tinted glasses and start preparing for a more renewable future.

Mark Baker,
Perth, WA.

Solar PV installation experience

The Publisher's Letter in the May 2015 issue highlighted some issues which may be of concern for those who have installed solar photovoltaic panels on their roof. The accompanying article in the same issue, detailing the experience of Dr Alan Wilson ("Home Solar Panel (PV) Electricity

Climate change comments should not be dismissed

It is with amusement that I again see the rise of intellectual arrogance in the Mailbag section (comments on the climate change debate, page 12, February 2015). To postulate that only specialists within the field of physics (or actually any field) can understand the details of climate change (or insert relevant topic: NBN, solar vehicles etc) and come to a "correct" conclusion is gross arrogance. I wonder what the other sciences think of the off-hand dismissal of their expertise and inputs.

If the general readership, which obviously includes the Doctor, know what the Gaia hypothesis is, then I would say this is a good place to commence discussion. To paraphrase, I don't have to agree with what you say but I will defend your right to say it. Discussion is the first step towards understanding. As noted in that letter, "real experts are rarely complacent or absolutely certain of their conclusions".

How dare you identify anyone outside your area of expertise as not being a so-called "real expert". History is littered with examples of where this constrained thinking has led to grievous errors in learning and development, even in physics! Secondly, if we are to wait for the statically "absolutely certain answer" we may be too late. The more hypotheses that are aired, then the more informed are the discussions and the greater will be the knowledge of what is occurring.

Experts and those with an in-depth understanding are required to balance the arguments and provide knowledge and guidance in what will ultimately be a community/political decision. In the final analysis, "the real experts" will only offer their "opinions" to the decision makers who, having other goals and agendas influencing their decisions, will set our environmental directions.

To stifle discussion is a crime that future generations will pay for.

Greg Budden,
Woomera, SA.

Comments about true-RMS voltage measurement

Thanks for the good article on the Appliance Earth Leakage Tester in the May 2015 issue but I have just one comment about "True RMS". I think you should point out to the readers that the RMS you referred to in the article is AC RMS and does not take into account any DC level that may be present. This is a trap for the unwary as True RMS readings take into account any DC level that may be present.

Remember the RMS value is equated to a DC level that would produce the same heating value in a resistor (power). So if you have a signal of 100V DC + 20VAC RMS you actually have 120V RMS!

Most DMMs that I am aware of do not measure this DC level; not even a good Fluke DMM – which I use. You have to switch to DC, note that reading, then add it to the AC RMS reading to obtain the total voltage.

Mike Abrams,
Capalaba, Qld.

Comment: measuring AC voltage when an accompanying DC voltage is present can cause problems for many multimeters. In those cases, it's necessary to measure the AC via a suitably-rated blocking capacitor. Some older analog multimeters incorporated ranges with a blocking capacitor and some DMMs have an AC+DC mode.

– is it worth it?") also raised some points which deserve consideration. Despite these concerns I am of the opinion that it is still worth doing today but various state governments are hatching plans to create disincentives to limit the take-up of solar PV installations.

I installed a solar PV off-grid system on my home in May 2009, when such systems were considerably more expensive than they are today. Prior to installing my system, I ensured that the roof area where it was to be installed was in prime condition. I have corrugated Colorbond roofing which had been in place for nearly 20 years but was still in very good condition. I made sure that all screws were replaced when fitting the solar panel mounting rails and that the roofing sheets were not likely to corrode in the foreseeable future. My home is located about 1.5km from the Indian Ocean so salt-laden air is not a real issue. However, I can see that those located right on the ocean may experience corrosion problems in the future.

My household consists of only my wife and myself (both retired) and we are careful to minimise power usage, although going to the trouble of switching off at the GPO all devices which run on standby power is going a bit too far I feel. The house is powered solely by electricity, augmented by a solar hot water system. The HWS electric booster is on a timer circuit so that it only comes into operation during the colder months and only operates for about three hours during the daytime to moderately heat the water for showering. Why waste electricity to make the water really hot when you are going to mix it with cold water and cool it down again?

My average power consumption prior to installing my system in 2009 was around 11kWh per day and my deci-

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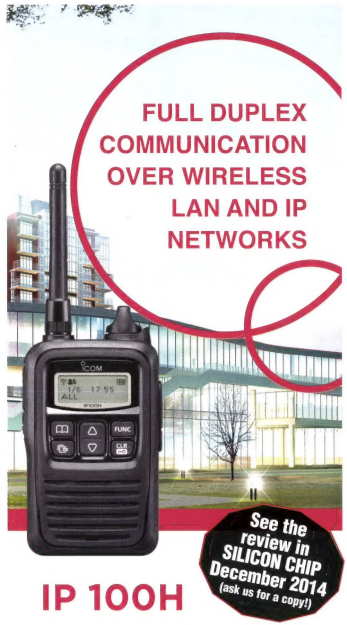

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Mailbag: continued

Omega VLF tower has been demolished

The former Omega VLF Tower near Woodside, in the Gippsland region of Victoria was felled on the 22nd April, 2015. The tower and the Omega Navigation System was the subject of my SILICON CHIP article in September 2014 and I mentioned the proposed demolition in Mailbag of March 2015 in which I suggested that concerned readers contact the relevant minister to oppose it.

This is a sad moment because: (1) this was the last tower left in the world that was used for the historically significant Omega Navigation System and not currently used for another purpose; (2) it was the tallest structure in the Southern Hemisphere and (3) it was a significant local tourist attraction and landmark which was also used for navigation by commercial fishermen.

Ostensibly, the reason given for demolishing the tower was that someone jumped off it, killing themselves. This seems to represent a new meme in government thinking. Does that mean that any other structure that someone illegally climbs and jumps off will also be destroyed? The implications of that are quite striking – no bridge, building or tower will be safe from the government wrecking ball. Whatever happened to the concept of individual responsibility?

It's too bad that no one in government seems to have understood the significance of the structure; nor cared. Everyone I know who has an interest in technology is appalled at the unnecessary and wanton destruction of the last tower standing that represented the navigation system that preceded GPS (former Station D in La Moure, North Dakota remains but was re-purposed).

No attempt appears to have been made to find alternative uses for the tower nor does it appear that the opinions of the public were sought on the matter. A video of this destruction can be seen at https://youtu.be/4YhZp4n1xys

I am glad I got to write the SILICON CHIP article and make a YouTube video (https://youtu.be/S_T7hd0oXUE) before this vandalism occurred.

Dr David Maddison,
Toorak, Vic.

sion to install solar PV was made in mid 2008 when it was mooted that electricity costs would rapidly increase within the next seven years. In 2008, WA was in election mode and Mr Barnett was proposing a solar rebate for exporting surplus electricity to the grid of around $0.60/kWh if he was elected. I quickly discarded this as blatant electioneering and it had no influence on how I voted. However, if this rebate did eventuate, it would have given some recompense against the high cost of installing a system at current prices, which in those days amounted to around $15,700 for a quality 1kW Sharp/Fronius package.

As it came to pass, Mr Barnett was duly elected and as I had surmised, he reneged on the idea of a solar rebate. The only rebate paid for exported electricity was to be at the same rate as customers paid for any electricity consumed from the grid. The federal government offered a rebate of $8000 in those days and together with selling my RECs for around $1000, it ended up costing me about $6700 out of pocket to install my system. Today, you can install a 3kW system for about half this cost.

As the price of solar PV products was dropping rapidly, the federal rebate of $8000 was cut since it was greater than the cost of purchase and would have just been a huge gift to home-owners.

I had always considered that a 1kW system was a too small for my needs and in February 2010 I purchased the items necessary to increase my system to 1.5kW. This would entail extra roof mounting hardware, three additional panels and the necessary extension cables to reach the end of the panel string. Even though I was able to get these items at a discounted price from a wholesaler, it still cost around $2900 all up.

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Mailbag: continued

Sprague 500 receiver used to hunt interference

I was just looking through the SILICON CHIP website and found the story on the Sprague 500 receiver in the September 2005 issue at www.siliconchip.com.au/Issue/2005/September/The+Sprague+500+multiband+receiver

I used this receiver frequently from 1967 through 1974 when I was stationed with AF Security Service in Berlin, Sinop (Turkey) and Shu Linkou (Taiwan). At all three places we had one at our front gate. If an entering vehicle broke the squelch they'd be barred from the facility until they got their ignition system fixed.

I frequently went off-site to hunt for RFI. Frankly, the Sprague 500 was a pretty good unit if you knew

how to operate it. We had a vehicle with an ignition suppression feature so we could be mobile. I found a lot of power-line interference, along with an occasional AM or FM station off frequency. In Taiwan, the ILS at Taipei airport often radiated past its limits.

Thanks for the memories.

Mike Dick, SMSgt, USAF, Ret.

Knob Noster, MO.

Because I performed the installation myself, I saved on that item but when all expenses were taken into account, my 1.5kW system ended up costing me a staggering $9600. As it eventuated, the WA government in 2011 decided to institute a nett feed-in tariff scheme which would mean existing owners would receive roughly 47 cents for each unit of solar electricity pumped into the grid. Not only this but the fee would apply for a period of 10 years. I quickly signed up for this offer.

In 2013, Mr Barnett was starting to have second thoughts about his generous buyback scheme and sought to cancel the 10-year contracts and only pay 27 cents for any excess put back into the grid. This sparked an immediate backlash – not the least of which came from voters who had helped put him in power at the last election.

After some discussion and lobbying, Mr Barnett eventually decided to leave existing 10-year contract conditions alone for those who had installed prior to 19 May 2011 and to effectively reduce the buyback fee to 27 cents per unit for those installing solar after this date.

Not satisfied that the revised energy buyback fees were sufficient to reduce the tariff being paid to solar PV owners, Mr Barnett was proposing to introduce at the budget this week a contrived "poles and wires rental charge", similar to that proposed in 2013 by the Queensland Competition Authority where it was suggested that a fee of $210 per annum would apply for those who use the public utility infrastructure to export their electricity back into the grid. I see now that this idea has proved too difficult to implement immediately so it has been put on the back-burner for a while. No doubt it will come up at some time in the future.

I find that my 1.5kW system contributes about 50% of my daily requirements year round so that with the feed-in tariff of 47 cents per kW I haven't had to pay for electricity for the past few years and have actually ended up with a credit on my account.

As far as my Fronius inverter is concerned, I have found it to be extremely efficient and reliable – up until about six months ago, just after the 5-year warranty period had expired. Since Fronius were now offering a 10-year warranty on current products, I imposed upon them to repair my inverter under warranty and they agreed.

I had done some research and found that the main board in inverters of the same vintage as mine were prone to a flash-over failure after about five years service, due to dust combined with atmospheric moisture ingress. It took about two weeks for a new board to arrive from Sydney and the serviceman to come around to install it. The new board was now coated (both sides) with a semi-flexible epoxy to a thickness of about 6mm. This measure was obviously to counter any similar failure mode.

During the time it took for the repair I decided to see what was available on eBay in the way of a spare inverter to keep on hand should a similar failure occur in the future. I was surprised when I found that a solar company only a few kilometres away was auctioning unused Fronius inverters of the same vintage as mine (they had acquired stock from a company which had gone into receivership).

I was successful in bidding on a slightly larger system (IG20) for around $430. This was about one-third what my original inverter had cost so I thought it was a good deal. When it arrived I removed the main board and masked off all connectors and components not requiring it, and gave it several coatings of acrylic conformal coating. The original IG15 which was repaired under warranty is now the spare.

Ross Herbert,
Carine, WA.

Output transformer failures may be due to paper composition

I have read with much interest the various comments regarding valve radio output transformer failures and I would like to put my view. Like John Hunter (Mailbag, March, 2015), I questioned Graham Parslow's reasoning that excessive anode current was the usual cause of output transformer failure (Vintage Radio, November, 2014).

Over the years, I have replaced many open-circuit output transformers. I usually "patch" a bench-test transformer and speaker across the output transformer to assess the overall operating condition of the radio before proceeding to fit a replacement transformer. In most cases, the resulting audio has been pretty good. If the coupling capacitor to the output valve was leaky enough to cause excessive anode current, the sound is usually pretty distorted.

My opinion on the causes of most failures parallels John's comments, with the addition of the following thought: it is my belief that a significant problem behind output transformer failures lies in the chemical composition of the paper used; either between the layers of turns or between the winding and the paper bobbin. I don't know the chemistry behind making paper but I believe that sulphur is (was?) used. An extension of this thought is fed by noting that people can buy "acid free" paper for archiving important documents. I also can't help wondering if the wax might not have been as inert as the transformer designers believed it to be.

A further comment: the Rola potted transformers that John refers to seem to have been prone to failure too, although maybe not as often as "open" transformers. I repair and restore valve radios myself and the Radio Corporation of New Zealand (RCNZ) which made Columbus and Courtenay (and other house brand) radios used "Isocore" wax impregnated transformers in cans. In their later model radios, Radio (1936) Ltd which made Ultimate (and also other house brands) used output transformers that were mounted on fibre washers to insulate them from the chassis and connected them to the B+ rail via a 470kΩ resistor. In both of these brands of radio, I note that output transformer failure seems to be about as "bad" as any other set I work on.

I would also like to comment on IF transformer and RF coil failure. These all seem to either go high in resistance or open-circuit on their primaries, all having been connected to the B+ rails. This definitely seems to follow John's reasoning on electrolysis but I still can't help wondering if the chemical composition of the paper is still the primary culprit. Many years ago, I remember reading that a thought held by the engineers at the time was this: it was often women who wound the transformers and coils and they speculated that maybe their perspiration got more acidic as they approached "that time of the month". There could also be some credence to their thoughts.

It's interesting to note that power transformers don't suffer from the same rate of failures as do transformers (or coils) that are connected to a DC voltage.

Further to John Hunter's comments about his belief in fuses. When I repair or restore a valve radio, I always install a 250V 1A 32mm long "fast blow" glass fuse in the Active lead of the power cord inside the radio. I had the unfortunate experience many years ago when I had nearly completed an overhaul

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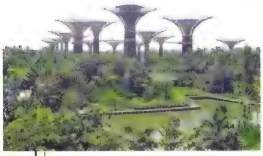
Mailbag: continued



Solar panel roof installations & nuclear power

In the May 2015 issue, the Publisher's Letter raised some very interesting points on the subject of solar panels. Even though at our home we have an ideal location for solar panels, we have resisted installation on the basis of cost per 10 years. Given that I am now into my 70s, there is unlikely to be any financial gain from going into such arrangement with our service provider. We did the sums and decided we would be better off to stay out of it (despite continuing calls from Mumbai around dinner time).

However, last year we were travelling through France and Italy and we noted the prevalence of solar panels, particularly in Italy. With regard to your comments about roofing, and we didn't have that incentive to get closer to the issue, but a lot of roofs in Italy are covered in solar panels and I am trying hard to recall but I think they were either the actual roof or very close to the roof so that any failure of the roof would be obviated.

One area which I noted as being an obvious location were car parks, where the shade for the cars was provided by solar panels – acres of them. The idea seemed to be to make carport style parking and use the solar panels as the shade roof; what a good idea! Unfortunately, most of this was seen while travelling at 300km/h on their highly effective rail system. Not only are the Italians good at opera but now at solar panel arrangements.

Strangely enough I didn't see such in Singapore but the Marina Gardens have a very high-tech waste disposal masquerading as garden styling, another area of "green" technology that seems to work.

I find the publisher's support for nuclear energy refreshing. As I grow older, I am more and more convinced that we in Australia should move to nuclear power. We have the advantage of having much open space in which nuclear power stations could be built.

We should also be building solar power stations like the La Florida one at Alvarado in Spain. Using liquefied salt as a medium it produces 432MW. We have the climate in which we should build several such plants across the country, thus providing some flexibility when cloud happens to reduce output from one of the plants.

However, I must say that I find an inconsistency in the publisher's use of scientific opinion to show that nuclear is safe, and rightly so, but yet he "cherry-picks" the small minority of climate change opposers. There will always be legitimate scientists who challenge the orthodoxy (that is how science works) but it is undeniably the case that the vast majority of climate scientists now firmly agree that climate change is man-made.

We must act now to reduce our carbon emissions and going nuclear and building the large solar plants is the way to achieve that end.

Ken Anderson,
Sale, Vic.

to a set that I had running well in my workshop as I went in to the house for my morning coffee. I went back out to the workshop about half an hour later to find the radio nearly on fire! The power transformer was extremely hot.

A subsequent postmortem showed that the phenolic rectifier socket had shorted (carbonised) across the HT pins (it would have had close to 750V across its adjacent pins, being a type 80 rectifier, if my memory is correct).

I can only assume that the socket had absorbed some moisture hydroscopically while the radio was in disuse and the stress of having about 750V applied was just too much for the poor socket to handle. I usually have a 200W lamp connected in series with the AC line to a radio while they're soak-testing but I was a bit too cocky that day and I paid the ultimate price – $500 to have the transformer custom rewound!

Peter Walsham,
Pukekohe, New Zealand.

Leo Simpson comments: I worked at Ducon Condenser Co in the mid-1960s and it was standard practice on the production line for polystyrene (Styroseal) capacitors (which had very high insulation resistance) for women who were menstruating to be taken off the winding machines and put on other duties – otherwise the wound capacitor elements were likely to have a high rate of rejection.

Airborne radar story correction

Your very interesting article on weather radar in the April 2015 issue refers to a company called ECKO. However, it should have been EKCO, as in Eric Kirkham Cole Ltd.

John Leathley,
Perth WA.

Acer netbook charger problems

Around 2010 I purchased a shiny new Acer netbook for my wife. It served her well for around 12 months but was soon made redundant by an iPad. The Acer sat in a cupboard for a little while before being passed on to my sister who had a need for it.

During this year's annual visit to my sister I noticed it seemed to be out of service again. On enquiry, my sister talked about her new iPad and full-sized laptop and said she didn't need the netbook any longer. I decided to bring it home at which point she also explained it no longer worked on the battery, only the charger.

Once home, there was no real need for a device with a dead battery and it didn't seem worthwhile to purchase a new battery given all the other new devices that I've acquired since the departure of the netbook. Back in the cupboard it went.

One day, when internet searching

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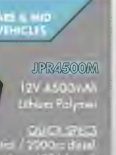

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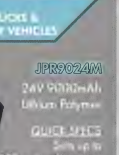

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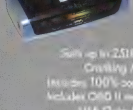

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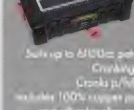

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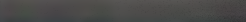

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Mailbag: continued

Valve servicing

I fix quite a lot of valve-based equipment. There are the usual dried up or leaky capacitors, resistors that have changed value or change as they warm up, dead valves and dodgy modifications.

One fault is common to all devices that mount the valve sockets directly on a circuit board: one or more joints will have cracked where the socket pins meet the board. I am supposing this is due to differential expansion and contraction as the socket heats up and cools down. This is also probably why point-to-point wired amplifiers are popular with musicians as they seldom have this fault.

I have devised a fix for the circuit board problem, which while a bit labour-intensive, does cure it for good. After carefully documenting the existing connections, I remove the socket and cut a circular hole in the PCB, large enough for the valve socket pins to pass through but small enough to leave some "meat" around the hole to allow the socket to mount via its lugs, spacers, 3mm bolts and a pair of small holes for the bolts to pass through.

I then carefully solder the valve socket pins to the appropriate tracks on the board, using small pieces of flexible hookup wire; different colours help with pin identification later on. Of course, this is made so much easier if the PCB is designed from scratch with the holes and some nice big square pads at the edge of the holes.

A PCB offers huge advantages over point-to-point wiring for the passive components but falls down for the power valves in particular. This solution offers the best of both worlds.

Derek Evans,
Daintree, Qld.

for something else, I came across a mention in a forum of a firmware update for battery failures in Acer netbooks. A quick check on the Acer website confirmed there was a new firmware update which was immediately downloaded and installed. After a reboot or two the system now identified the battery and began charging.

I guess not all fixes are for a physical failure; it was only the long period of non use that had allowed the battery voltage to drop below a threshold the original firmware could not recharge the battery from.

Anthony Vine,
Tanilba Bay, NSW.

Potentiometer testing tip

I've been a bit of a train buff since I was young and the performance of the train I'm on is of special interest to me. To find out how fast the train I'm on is travelling, I usually take note of the time between the kilometre posts, although at higher speeds, it is sometimes hard to spot the posts.

People have suggested to me that perhaps a GPS would do the job but I'm a bit unsure if it would be reliable on a train. The windscreen in a car is swept back so a GPS attached to the windscreen would have good access to satellites fairly much overhead but on a train with windows that are vertical, it would mean that only satellites closer to the horizon could be used.

In addition, many train windows are tinted and I understand that the tinting on the V'locity trains here in Victoria and the XPT in New South Wales is a metallic film-type tinting which may have an attenuating effect on the signals. So do you think it would work or would it be a bit unreliable? I suppose I should try to borrow one and go for a quick train trip and try it out but I'm not sure that any of my closer acquaintances have one.

On a different matter, this little tip may be of use for your readers. I'm one of those electronics constructors who use salvaged components wherever possible. It can be a bit frustrating to find that a potentiometer which appeared to be OK when checked with a multimeter turns out to be noisy. So now before re-using a pot, I always do this simple test. I connect a bench DC supply across the outer terminals (the actual voltage is not particularly important; 5V or thereabouts is OK) and connect my oscilloscope between the wiper and one end.

I then select AC-coupling and a fairly high sensitivity in the millivolt region and slowly rotate the shaft. Any "noisiness" which a multimeter would miss is very obvious on the trace. If it is minor, a squirt of contact cleaner usually fixes it but if there are noticeable drop-outs then it's into the bin for the pot!

Ray Chapman,
Pakenham, Vic.

Comment: we expect that a GPS Sat-Nav could work but it would depend on reception conditions on the train and the GPS module's sensitivity. It should certainly work on a train with wooden carriages. The only way to know is to try it.

Thanks for your tip on testing suspect noisy pots.

Vintage scopes for a good home

I would like to place the following note in SILICON CHIP, if possible, as it just doesn't sit right with me to have to throw this old equipment away without at least offering it to someone.

I have been employed at a power-generating company since the mid-seventies. Recently, I stumbled across these three oscilloscopes that were once used to service communications equipment of that era (see photo). I have not switched them on because I believe they should be thoroughly checked first.

These units are now destined for the scrap-heap so if anyone would like them for free, they can either pick them up or be willing to pay the freight costs and I will send them.

Please contact me at the following email address: big.penguin@bigpond.com

T. Ives,
Penguin, Tas. SC

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There are now several electric-only vehicles being sold in Australia but the only one which is real competition for high-performance luxury cars is the Tesla. That's because the Tesla is a luxury, high-performance car in its own right. High-performance, though, is almost damning it with faint praise!

The first thing you notice about driving a Tesla is its acceleration. It quite literally pushes you back into the (very comfortable leather!) seat and you think WOOOOHAAAA!

It's been compared very favourably with that of a Porsche or Ferrari but having never quite got to own (or even drive!) one of those lofty marques I cannot comment.

However, I can say (because Tesla told me!) that over 200m, the new two-motor all-wheel-drive Tesla P85D (not yet available here) will blow a very much more expensive Ferrari FF or the popular Porsche Panamera Turbo into the weeds! (The Ferrari FF starts at about $US300,000; the Porsche Panamera ranges from about $US78,000 to >$US200,000).

The P85D will post a 0-160km/h time of just eight seconds and has been clocked at 3.2 seconds for 0-100km/h.

I can, however, comment on the very next thing you notice: the speedo reading. In the blink of an eye (or two) you can easily be going FAR above the speed limit. (I was; fortunately there were no speed radars around . . .).

Top speed of the S85 is a rather impressive 225km/h. And no, I didn't try to prove it.

Incidentally, that model number (70, 85, etc) refers to battery size - 85 is for the 85kWh model.

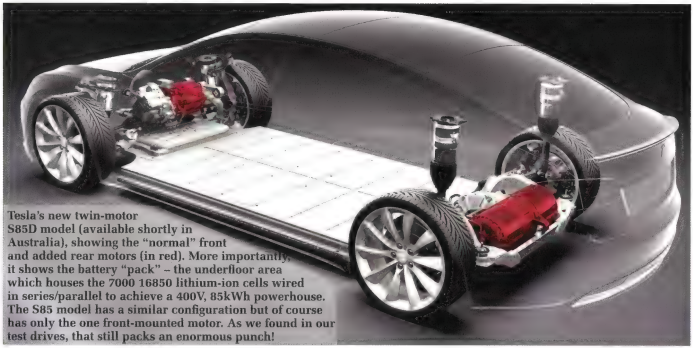
It's a true PEV

Having come from a PEV environment (that's Plug-In Electric Vehicle for the great unwashed, as distinct from PHEV, or Plug-in Hybrid Electric Vehicle. See the following column "*Owning* an Electric Car") I was well-used to the almost total lack of sound when driving.

OK, there is some road (tyre) noise; at speed there is a tiny amount of wind noise (more a whisper!) but most of the time there is no noticeable noise. The Tesla is little different in this regard. The much larger (18-inch or even the optional 21-inch) tyres are obviously partly responsible for slightly more road noise but it's certainly not objectionable.

Where conventionally-powered cars have to go to some lengths to achieve a relatively noise-free ride, the Tesla (and we have to say other electrics) do it almost by default.

What sets the Tesla apart from other pure electrics is the amount of power available and almost contrarily, the amount of range. (Usually, electric vehicle high power/performance is at the expense of range. Not so much here).



Tesla's new twin-motor S85D model (available shortly in Australia), showing the "normal" front and added rear motors (in red). More importantly, it shows the battery "pack" – the underfloor area which houses the 7000 16850 lithium-ion cells wired in series/parallel to achieve a 400V, 85kWh powerhouse. The S85 model has a similar configuration but of course has only the one front-mounted motor. As we found in our test drives, that still packs an enormous punch!

In the Model S85 we had for (unfortunately an all-too-brief) review, it was VERY obvious that this vehicle was so far ahead of any other pure electric that there really was no comparison. Impressive? Not just yes but Hell YES!

Then again, at the price I guess it would have to be. The basic model sells for more than twice the price of the next most popular electric vehicle in Australia, the Nissan LEAF.

Yes, we are completely discounting hybrids such as the Toyota Prius, Holden Volt etc, because these are not electric vehicles. They are petrol-powered vehicles with limited battery capability (in the case of the Prius) or with a battery charged by a petrol motor (in the case of the Volt).

Where are they from?

Tesla vehicles are fully imported from the USA. They're built in a plant in Fremont, California, which is a story in itself.

The Fremont plant was previously used to build GM and Toyota vehicles in a joint venture called NUMMI. Covering an area the size of 88 football fields, a section was purchased by Tesla (reportedly for the proverbial "song") after NUMMI ceased production in 2010.

The Tesla plant today bears little resemblance to the original, with significantly more automation and everything painted gleaming white to reflect the total build quality demanded by Tesla and its CEO, Elon Musk.

The company

Various news items in 2012 and 2013 had Tesla Motors in significant financial trouble, with many financial gurus (and, it must be said, other grinning car manufacturers) forecasting its imminent demise. Indeed, it was reported at the time that Elon Musk was on the verge of selling Tesla Motors to Google (and later confirmed by him).

However, vehicle sales picked up so this sale never progressed. Tesla kept on producing cars - and reported a

A night-time view of the Tesla S85 controls featuring that magnificent A4-sized touch screen display. Virtually every vehicle function can be controlled from this screen or it can be used to display the view "out the back" or as seen here, the GPS navigation system.

Back-seat passenger's view of the S85 console. Impressive, isn't it?

positive cashflow for the first time in the last quarter of 2013.

Tesla's share price (Nasdaq TSLA), which opened at $US19.90 in August 2010 was more than ten times this (~$US226) at the end of April 2015.

In the first quarter of 2015, they delivered more than 10,000 new vehicles but production capacity does not satisfy demand. The result is that for most models there is a long "wait list" (in Australia, you are looking at October/November delivery for vehicles ordered now).

Tesla's sales model does not include dealers – you buy direct from Tesla (from their company-owned showrooms). This has got Tesla into some difficulty in the USA, where the powerful auto unions have been able to convince legislators in several states to disallow Tesla's setting up showrooms in those states.

The car

You have to say this is one good-looking car. In fact, I noticed a lot of people admiring it during the day I was driving it around. The shape and styling has often been compared to several up-market competitors.

It's not a small car by any means; at 4976mm long, 1963mm wide and 1435mm high, its not dissimilar to a large, family sized luxury sedan (think BMW 7-series, for example). But at 2.1 tonnes, it's probably about 500kg heavier than most of its competition – thanks largely to the 700kg, 400V battery pack.

Inside, there's plenty of room for a family of five (in very comfortable leather seats, with tons of legroom, even in the back).

And because there is no pesky transmission tunnel, as you would find in all front-engine, rear-wheel-drive cars, the middle back seat is not cramped up.

Luggage space is not skimped on, either, with 894 litres spread between the boot and bonnet, that's quite a lot more than any car not specifically designed to carry loads (even then, it beats several mini vans!). Fold the rear seats forward (and flat) and capacity increases to 1800 litres.

Just in case you missed that "boot and bonnet", the tiny engine size means a lot more extra space than you might expect. And the lack of a bulky petrol tank helps a lot. Both front and rear luggage areas are fully carpeted.

The instrument "panel"

The first thing you'll note when you sit in the driver's seat is the huge LCD touch screen in the centre of the dash. It's hard to explain just how striking – and clear – this screen is!

At 430mm diagonal, (a bit deeper than the size of an A4 sheet of paper) it is mounted vertically into the dash. It can be set to have two horizontal half-screens or a single vertical full-screen.

It's not just an information display – it's also the mechanism by which the vast majority of vehicle settings, operating information and preferences are displayed and/or altered.

It's also the navigation screen – magnificently clear and detailed (much more than typical vehicle GPS screens) and it can be made full screen if you wish to either cover a greater area or obtain even more detail. And it also displays the images from the rear-facing camera, again, in far more detail than any vehicle camera we've ever seen. Once again, you can have half screen or full screen.

Entertainment system

We haven't mentioned the Tesla's extensive audio/entertainment capabilities – which are superb. You get the choice of several modes of radio (including internet radio and a couple I didn't even recognise!) plus wide-ranging audio sources – again, either your CDs, DVDs, MP3s, cloud-based storage, internet music sources and much more. The

Here's another view, this time 3/4, of the Tesla Model S showing the beautfully clean lines and styling, which attracts a LOT of attention! It's been compared very favourably with some much more expensive marques. This could make the Tesla an attractive target for thieves. But unless they have the unique key, good luck with that! Even then, with Tesla's smartphone app, you can see where your Tesla is at any time to within just a couple of metres. The car features an incredible amount of electronics and "creature comforts".

premium audio system is reported to have been developed "from the ground up" by Tesla but other reports suggest Alpine might figure in their somewhere.

"Starting" the Tesla

As you approach the Tesla (assuming, of course, that you have the key) the main thing you notice is that the previously flush door handles move out, ready to open the doors.

There is nothing, as such, to "start". Entering the car and sitting in the driver's seat lets the system know you are ready to "rock and roll". Just about everything is automatic.

Placing your foot on the brake and moving the "gearstick" (which is merely a stalk on the *right-hand* side of the steering column) to F or R sets the car ready to drive. Take your foot off the brake and it will gently start rolling – as long as you have previously set it to "creep". A word of warning: don't plant your foot on the accelerator or you'll probably leave your breakfast back where you started!

Incidentally, proving that software developers have a sense of humour, Tesla engineers have labelled the two-position acceleration mode settings "sport" and "insane"!

"Starting" also initiates all the other processes that go on in the car. If you've entered a personal profile, it adjusts everything (seat position, air con, driving preferences, etc) to that. If not, the previously used setup is resumed.

Now you can also set up profiles, navigation and so on for this trip. Obviously, this should be done while stationary, - setting up while mobile is definitely not recommended. Most setup is done on that beautiful, big touch screen right in the middle of the dashboard. Even "stuff" that has external controls is mostly accessible via that screen as well.

Exiting the car

This takes a little bit of getting used to, because you don't turn a key off or even push a button – there is nothing to shut down. The car simply "goes to sleep" when you put it in "P" (for Park), lock the door and walk away.

It's a bit disconcerting to look in through the window and find the dashboard still activated, the touch screen still displaying pictures or vehicle data . . . and so on.

But walk away from the car (obviously taking the "key" with you) and very quickly it all shuts down by itself.

The motor

In the S70 and S85, a single 310kW, 600Nm three-phase AC induction motor drives a single speed 9.73:1 gearbox which drives the rear wheels. The gearbox only has forward and reverse (and neutral/park) options selected by a stalk on the right-side of the steering column.

The motor occupies quite a bit less space than an internal combustion engine – sure, there are ancillaries such as the AC inverter, air conditioning unit and so on but the result is the "engine bay" is rather roomy, so much so that it is given over to luggage space.

The S85D model, when available here, will have two electric motors (totalling 515kW and 931Nm) and drive all four wheels.

The battery pack

It may surprise you to find that the lithium ion battery pack consists of many thousands of small cells – in fact, "18650"-sized 3.7V cells (or 18mm diameter x 65mm long, the same as found in many small rechargeable consumer products, toys, etc) are connected in series/parallel to achieve a high capacity (85kWh), high voltage (400V) battery.

This is housed under the floor of the vehicle and is in fact a stressed member of the chassis, helping provide rigidity to the rear of the car. This also brings the centre of gravity to the lowest point possible, considerably helping with the car's roadholding.

Tesla's batteries, supplied by Panasonic from Japan, have an energy density of 121Wh/kg, which are the most energy-dense packs in the industry. Compare this to the Nissan LEAF's energy density of 79Wh/kg and its not hard to see why the Tesla range is so significantly higher.

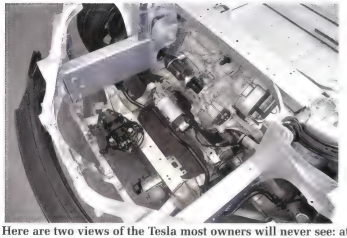
Where are the Australian government electric vehicle incentives?

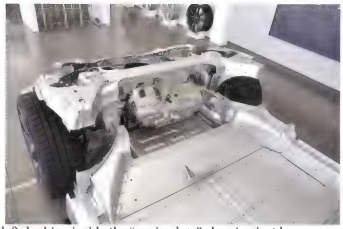
In most countries overseas, governments encourage electric car purchase through attractive (sometimes VERY attractive) incentives. These range from discounts or rebates of taxes, "green" incentives, use of transit or special lanes, reserved parking (often with free charging facilities) and so on. For example, the US federal government offers a $7500 federal tax credit for personal PEV purchasers. And some states top that up with another rebate ($2500 in California, for example).

The UK has several incentives, ranging from a £5000 government grant, to no road tax, showroom tax or luxury vehicle tax and even an exemption from London's congestion charge. For companies, they offer a 100% first-year write-down allowance.

Here in Australia, there is little government incentive to buy an electric car. The government's luxury car tax is less for a fuel-efficient vehicle (woopie doo – that applies to all fuel-efficient vehicles), while in the ACT electric vehicles attract no stamp duty.

But that's about it. In NSW, the incentives and/or reductions amount to a very round number.





Here are two views of the Tesla most owners will never see: at left, looking inside the "engine bay" showing just how little room the engine actually takes. The rest are things like air conditioners, gearboxes, and so on. When completed, the whole of the additional space is given over to luggage space. The view at right is from the other side of the engine, over the battery compartment, from what would be cabin space.

As mentioned earlier, there is a choice of 70kWh or 85kWh batteries. Until recently, Tesla offered a cheaper 60kWh battery pack. While slightly smaller than the current model's packs, this 360V, 459kg battery gives a good idea of the way so many cells are packed into the space.

In the 360V battery, 69 steel-cased cells are wired in parallel to form a "brick"; 99 bricks are connected in series to form "sheets" and 11 sheets form the whole battery pack – a total of 6831 cells. The battery is liquid-cooled and cell temperatures are constantly monitored by internal sensors.

Lithium ion cells cannot be charged when they're below 0°C, so if the temperature approaches zero the cells are heated at the same time as they are being charged. At the opposite end of the temperature scale, above a set threshold, cold air from the vehicle's air conditioner is directed through the pack to allow charging in very hot climates.

Because lithium ion cells contain neither heavy metals nor toxic materials, at the end of their life the battery packs could theoretically be disposed of in landfill. However, Tesla goes one better: it has a recycling program which reuses or recycles over 60% of the battery already and aims to increase that to 90% in the future.

New battery "gigafactory"

Tesla is currently building a $5 billion dollar battery research and lithium-ion manufacturing facility on a 980 acre site outside Reno, Nevada. This alone is worth a story (and many have been written!) about the way Elon Musk and his team managed to build this mega-factory with $1.4 billion in tax breaks, free land and other incentives from the state of Nevada.

Looking to the future, the company has options on another 9000 adjacent acres, which includes 7000 acres for a 140MW wind-farm.

It will be a net-zero-energy factory, powered by renewable energy – solar, wind and even geothermal.

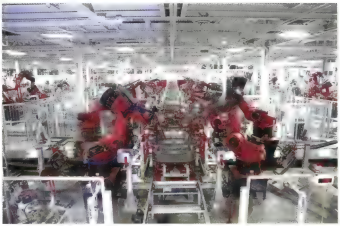
Production will be ramped up from 2017, with 50GWh in annual production by 2020.

The rear-view camera vision quality is superb – as good as any we've seen. Here the screen is shared with GPS navigation – either can be made full screen.

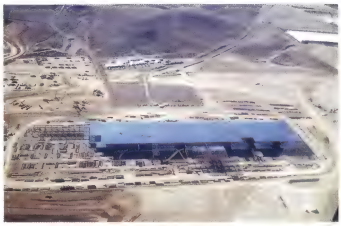
Just a tiny part of the Tesla's comprehensive entertainment system – all touch-controlled, of course. It remembers your favourites so you don't have to go hunting for them.

It's telling me that I have 311km of range left in the battery – but you wouldn't discharge to flat in order to give your battery the maximum lifespan.

Just about everything can be controlled from the touch screen, even such niceties as mirror tilt (in reverse) and mirror fold (when you stop and get out of the vehicle).



Inside Tesla's manufacturing facility at Fremont, Cal, USA. The plant, now gleaming white inside, once manufactured GM and Toyota vehicles . . . and went broke! Tesla was reported to have bought the plant for next to nothing!



Here's Tesla's huge new $5 billion battery production and research centre now under construction near Reno, Nevada, USA. The whole of the roof will be clad in solar panels and the building energy self-sufficient.

Strangely enough, some reports suggest that Panasonic will still make the li-ion cells in this factory. But according to other reports in recent months, Tesla will also be manufacturing a range of large home and industrial batteries to either store solar power generated during the day or even store low-cost off-peak power for use during much more expensive peak times. (See the report "Tesla's PowerWall" later in this issue.)

It remains to be seen how successful this side of the enterprise will be – but if Elon Musk has anything to do with it . . .

Charging, range anxiety etc

With a quoted range of up to 500km per charge, most Tesla owners don't suffer anything like the "range anxiety" owners of other electric cars experience. This can only improve in the future, with Tesla Australia planning to locate their "Supercharger" charging stations at suitable distances along the routes between eastern capitals – from Sydney to Melbourne by the end of 2015 and Sydney to Brisbane by the end of 2016.

The Supercharger provides up to 135kW, giving 85kWh models almost 300km range in about 30 minutes. So basically it's stop for a coffee, stretch your legs and charge the Tesla at the same time.

500km is more than enough range to travel, for example, from Sydney or Melbourne to the snowfields (where the car could be charged from ordinary power). It would also allow a single (or at worst two) stop trip between Melbourne/Sydney or Sydney/Brisbane.

Tesla currently has Superchargers at its St Leonards showroom and also at the Star City casino (both in Sydney). We understand that Superchargers at the Tesla showroom in Chadstone (Melbourne) are imminent, if not already available. Tesla has recently announced a Supercharger for Goulburn, to add reassurance to the Sydney/Canberra journey.

Tesla vehicles may also be recharged (albeit usually at a slower charge rate) at the many public charging stations now emerging around major cities. There are currently more than 200 public and private charging stations in Australia.

A 230VAC single phase EVSE (Electric Vehicle Supply Equipment) "smart cable" is also included in the price of a Tesla – this must of course be installed in the owner's premises at their cost.

In December 2014, Tesla (USA) announced that they were embarking on a battery pack swap program with invited Tesla owners. While still a pilot program (and not available in Australia) Tesla is confident that if and when implemented, the battery pack could be swapped for a

When the right side of the speedo shows green, the Tesla is putting power back into the battery (via regenerative braking). Above this is an orange zone, showing the power (in kW) being used at the time. The left side is a conventional speedo; a digital equivalent is displayed in the centre.

Is lithium-ion *still* the way to go?

Tesla is putting an enormous amount of faith in the lithium-ion rechargeable battery it currently uses to power its vehicles.

But many critics are already saying that just as lead-acid batteries have had their day, the lithium-ion cell is also on the way out, promoting instead the aluminium-air batteries currently being developed by several organisations around the world.

An aluminium-air battery generates electricity from the chemical reaction of oxygen (from the air) and aluminium, using water as an electrolyte. Their theoretical capacity is some 40 times greater than a similar-sized lithium-ion cell.

Until now, however, this approach has been stymied by the reaction consuming the aluminium anode, which must be physically replaced rather than recharged.

Last January, Japanese company Fuji Pigment announced that it had managed to suppress corrosion and reaction by-products, creating an aluminium-air battery that can be recharged by simply adding water.

Ahh, isn't that the holy grail: when "fill er up" means grabbing the garden hose?

Luggage space can only be described as cavernous – and there's up to 1800l with the rear seats folded forward.

Almost hidden in the front bumper is the Tesla's forward-facing radar unit which is part of the anti-collision system. Get too close to the vehicle in front and the Tesla will slow you down, or even bring you to a complete stop if necessary.

fully charged pack in less than one minute (less time that it takes to fill a fuel tank!) and would indeed cost less than a tank full of fuel.

This program is being evaluated to test technology and assess demand – ie, whether they are prepared to pay a small amount for a lightning-fast "charge" by swapping batteries, or would they prefer to fast charge at one or more "Supercharger" rechargers, at a rate of 640km range per hour of charge (or a full battery in less than an hour).

The third option, obviously, is to charge at home or at a standard rate charger. The advantage of the latter is that many of these are free to use!

While on the subject of range, Tesla assured me that the range displayed on the dashboard has proved to be extremely accurate, much more than that of (ahem!) the Nissan LEAF. Whether this is true or not is open to conjecture because any number of on-line forums state the opposite – they claim the "300 mile" range quoted by Tesla is much more likely to be in the low 200s, and sometimes worse.

Once again, it all depends on the way you drive, the temperature outside the car, the terrain, the state of charge (and the state of battery) . . . all those things which affect all other electric cars.

Cost to charge

How much does it cost to charge a Tesla – and therefore, how much does it cost to run?

That is a rather difficult question to answer because there are so many variables – the amount of charge left in the battery, for example, the cost of the mains power being used and even your electricity usage (high power users usually pay a premium).

We've already mentioned that Tesla's SuperChargers, many street-side and carpark chargers don't actually charge you for power, so if you can use one of those at least most of the time you're streets ahead! Note, though, that many do have a cost – but they're not charging sheep stations (no pun intended).

If you have to pay for power (eg at home), we've been assured that EVSE equipment can legally be connected to "off peak" circuits. In most capitals this costs less than 10c per kilowatt-hour. Or, if you have a smart meter, charging during the lowest rate period (usually 10pm-7am) will also get you similar rates.

So if, for example, you're charging at the rate of 10A (2.3kW) it's going to cost you about 20c/hour to charge. If your (pay-for) charging station can deliver the (often very!) much higher charge rates the Tesla can handle, multiply up!

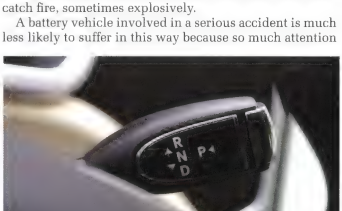
For example, when I returned the review Tesla it was plugged into the St Leonards Supercharger and displayed a peak charging current of some 400A (92kW!) for half an hour or so, dropping quickly as the battery charged. At off-peak rates a full charge might cost a few dollars. Remember, though, that gives up to another 500km range.

Battery safety

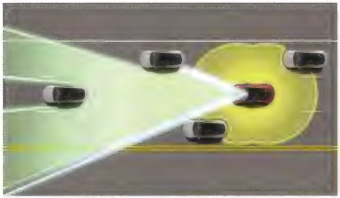
Overseas (notably the US), there have been a few highly-publicised Tesla fires. However, given the number of Teslas now on the road, that number is very small – and analysis by Tesla and accident investigation authorities has not shown any cause for major concern. In fact, one report said that if it was anything but a Tesla, the outcome for the occupants would arguably have been much worse.

When a petrol-powered vehicle has a serious accident, there can be a lot of fuel released and it can (and often does) catch fire, sometimes explosively.

A battery vehicle involved in a serious accident is much less likely to suffer in this way because so much attention



The gear selector is actually a stalk on the right side of the steering column. That took a bit of getting used to – every time I went to turn left I put it into neutral . . .



The green and blue beams in front of the car come from the on-board radar systems, while the yellow shading shows how the Tesla senses vehicles all around through its camera systems. The company has already demonstrated experimental autonomous (so-called "driverless") cars using this and even more advanced technology.

Yes, it was a demostration for the media but last year Elon Musk showed how quickly a Tesla could have its batteries changed – in fact, two Teslas had batteries swapped in the time it took to fill an equivalent petrol vehicle with fuel. Tesla are working on a pilot program to see if battery swapping would be popular enough to be viable.

has been paid to shielding the battery pack against external damage, through the use of protective enclosures and jacketed cables. Even access to the high-voltage components requires special tools.

In the event of significant impact or rollover (including air bag deployment), the high-voltage supply is automatically disconnected inside the pack. Universal (international) marking codes are used to enable first responders to disconnect power safely.

Built-in safety

Tesla sports an independent 5-star safety rating, not just in all their models but in every subcategory (the highest score ever recorded). There are so many safety features inbuilt (or available as options) that it is difficult to list them all.

But one which caused us some brief angst, believe it or not, was the car's out-of-lane warning – only because we didn't know what the vibration was all about (it's almost like a really bad tyre balance problem)! Tesla told us that was a particularly common "complaint" amongst new Tesla owners, like "what's wrong with my car!!!". They're happy to say "nothing" but then it becomes a diplomatic problem to suggest "it's your driving!".

There are four cameras built into the Tesla, one, rear-facing, is for the brilliantly clear rear-view video screen.

The "charging port" is located just in front of the left rear tailight assembly. Quite extensive charging information is displayed on both the dashboard and LCD screen.

Two others at the sides look for the white lane markers – they're the ones which warn you if you're drifting – while another, forward facing, is for anti-collision avoidance in conjunction with a bumper fitted radar. It first warns you, then takes action, if you are too close to the car ahead at the speed you are doing (it will even bring the car to a complete stop if necessary). The thresholds are all settable.

One query I had was if any of the cameras recorded, a la a "dash cam". Unfortunately, the answer is no, although I wouldn't imagine it could be that hard to implement at factory level. Still, amongst all the incredible technology already in the Tesla, it's a small quibble.

Where's my car?

When I first saw the LEAF, Nissan told me it had an inbuilt 3G phone system which called the company every night with operational data. I asked if this could be used to interrogate the car to check its location (eg, if it's stolen). Nissan told me that Australian privacy laws meant this could not be done (they'd tried, very hard).

Obviously Tesla had no such problem. They too have a built-in 3G data system but theirs can also tell you (eg, via a smartphone app) exactly where the car is. Tesla's service manager showed me where the five cars on hand were – within a couple of metres (including the one I was standing alongside).

So if (somehow!!) your Tesla is stolen or hijacked, you can see exactly where it is. It's the same technology that allows Tesla to wirelessly update the software and firmware which runs the car, or allows the owner to wirelessly set charging parameters, climate control and so on.

Autopilot

Reports recently have suggested Tesla is well on the way to producing a driverless car. This could be a natural spin-off from the Tesla's "Autopilot" option, where the vehicle automatically follows the road, steering around curves and varying its speed to match traffic flow. It also allows automatic lane changing – tap the indicator and the Tesla changes lanes when it is safe to do so!

It will also notify you when it finds a parking spot – then automatically parks in it, controlling steering, acceleration and braking to back smoothly in.

Inside each Tesla showroom you'll find their "Design Studio" which lets you choose colours and trims, wheel types and so on. The car will be made to your specifications in America and delivered to Australia.

Another nicety: sync your calendar/diary to the car (via your smartphone) and it will check current traffic conditions to make sure you leave in enough time to make your appointment. Before that, though, it turns on the climate control to your chosen (preset) levels. It can even automatically open the garage door and pull out of the garage by itself, to meet you at the curb!

Yes, many of these things are options but they do give some indication of the sophistication (for want of a better word) built in to this remarkable machine.

Machine? I reckon it's almost human!

Where to from here?

We've only been able to cover some of the rather amazing inclusions in the Tesla S85. There's plenty more information on Tesla's website(s) and numerous third party forums and websites if you wish to know more. But if you are at all interested in having your own Tesla, we suggest getting onto their Australian website and organising a test drive. You won't be disappointed!

We've already mentioned the all-wheel-drive, twin motor S85D model already released in the USA and not too far off here (but join the queue if you want one!). From the outside, apart from a couple of badges it's the same as the S85 model . . . until you "lift the lid". Its performance, subject of numerous tests overseas, is simply outstanding. Adding the second motor sacrifices a bit of range (<10%) for greater speed and even more neck-snapping acceleration, with 0-100km/h in just over 3 seconds.

And then there's the all-wheel-drive two-motor S70D announced only a few days ago (it's not yet available in the states so will be some time coming to Australia).

Musk has stated that he aims to have a "Tesla for the masses" before too long. With a cheaper battery (which is not too far away) he aims to have a $US35,000 Tesla available by about 2017.

And we've already mentioned Tesla's incursion into other battery applications – and their continual research into extracting every last milliamp from the cells. They're reported to be well advanced in nano technology, increasing the internal surface area of cells – and therefore making them perform even better.

Elon Musk stated that the new Reno facility, which will cost about $5,000,000,000 (yes, B for Billion!), should be online and producing batteries by the end of 2016.

He's also said he wants that plant to be able to make half a million battery packs each year – and that's equal to the whole world's current production!

Impossible? Maybe . . . but "Do the Impossible" is one of Tesla's slogans. SC

Our thanks to Heath Walker and Huw Williams of Tesla Australia for their assistance in making the S-85 available for review. Photo credits: Tesla, Kevin Poulter and Ross Tester

TESLA MODEL S – SPECIFICATIONS

Body

Length:	4980mm
Wheelbase:	2960mm
Width:	2190mm (With mirrors folded 196mm)
Track Front:	1660mm, Rear 1700mm
Clearance:	140mm (With air suspension 120 - 160mm)
Head room:	Front 990mm, Rear 900mm
Leg room:	Front 1080mm, Rear 900mm
Turning circle:	11.3m
Curb weight :	2112kg

Drive

Battery:	70kWh or 85kWh, lithium-ion battery, microprocessor controlled
Motor:	Three phase, four pole AC induction motor with copper rotor
Drive inverter:	Variable frequency drive and regenerative braking system

Charging

10kW-capable on-board charger with the following input compatibility: 85-265V, 45-65Hz, 1-40A (optional 20kW-capable dual chargers increases input compatibility to 80A)
Peak charger efficiency: 92%
10kW capable Universal Mobile Connector with 120V, 240V and J1772 adapters

How much, where from?

The Tesla S85 that we had for review sells for $AU129,000 on the road.

The new S85D will, when available sell for $169,000 on the road.

There is a slightly lower cost S70 available which also lacks some of the "niceties" (but is an outstanding vehicle nevertheless) and it sells for $99,000 on the road. An S70D (all wheel drive, two motors) has also recently been announced in the USA.

You can't walk in, pay your money and drive out with a Tesla. There's quite a waiting list (several months), to some degree caused by the inability of Tesla USA to meet international demand.

To get on the waiting list, (or even to organise your own test drive) you need to get in touch with Telstra Motors Australia, 10 Herbert Street, St Leonards NSW 2065. Tel (02) 8424 9500, website www.teslamotors.com/en_AU

Real "Hands On": *Owning* an Electric Car

Readers may recall that we have previously reviewed two 100% electric cars: the Mitsubishi iMiEV (February 2011), followed by the Nissan LEAF (August 2012).

We also tried to get hold of a Holden Volt when they were released but are still waiting (two years later) for the General's PR people to get back to us!

It's probably just as well that we didn't get to review the Volt because unlike the iMiEV and the LEAF, it's not a true electric car – yes, it runs off batteries but has a small petrol motor to charge those batteries. Therefore, it requires fuel, not too dissimilar to other "hybrid" electrics such as the Prius, some models of BMW, Lexus and Toyota Camry (among others).

"Hah hah hah. . . you'll need a l-o-n-g extension lead!"

We were particularly impressed by the LEAF. I recall saying that if I had a spare fifty grand, I'd buy one. I didn't – so I didn't!

Circumstances change, not the least being a $12,000 price drop so last June (and prompted by a failing 16-year-old SUV) I bit the bullet . . . and bought a LEAF.

I did this with my eyes wide open – I'd read everything I could find and knew that it was *strictly* a commuter car with limited range. My partner has a Hyundai ix35 – if we wanted to go away any distance we would take that. So yes, you pretty-much need to be a two-car family OR be prepared to drive your LEAF to the airport and (if you need one) hire a car at your destination.

But there were a few things I was to discover about the LEAF only after regularly driving one for nine months or so.

First of all, I have to say that I am very, very happy with the LEAF. It's by far the smoothest car I have ever owned (or until the Tesla test review even driven) and it is by far the quietest.

I'm also extremely happy with its performance. Normally, I'm a pretty sedate driver but if I *really* want to get away first at the lights, I can virtually always do so – even against some "performance" cars. The LEAF has incredible down-low torque and acceleration.

I'm also rather happy with my "fuel" consumption.

Normally, I limit the charge (automatically) to 80% of capacity, as suggested by Nissan to maximise battery life, and require a charge (usually) only about twice a week. While the supplied "charger" is fitted with a 15A mains plug (and therefore requires a 15A dedicated outlet) I've measured the charge at 9.75A (@230VAC), with no real difference between a full battery or a half-charged battery.

My first electricity bill with the LEAF was almost exactly $100 more per quarter than the corresponding quarter the year before. When petrol was between $1.00 and $1.30 per litre last year, I would have put $100 in every 2-3 weeks! So it's not too much of a stretch to say that my "fuel" bill has dropped by ~75%! Of course, petrol prices dropped significantly in late 2014/early 2015 but as I write this, they're creeping back up again. . . I'm laughing!

But what about the negatives?

Apart from the legion of "hah hah – you'll need a l-o-n-g extension lead" jokes, the only "biggie", as far as I am concerned, is range. The official figures are just a tad optimistic!

Nissan claim "up to 170km range" on a full charge. There are the usual disclaimers about how and where you drive, temperature, etc – just as you might expect in a petrol or diesel-powered car.

There's even a cute "range gauge" on the dashboard which tells you how much battery charge (in kilometres) that you have left (sort of like a fuel gauge in reverse).

Have a look at some of the online forums and you'll find some pretty disrespectful names for this. Some of the more genteel refer to it as a "guessometer". Good name, that!

As my commute to work is <10km, 95% of the time range doesn't matter to me but the very best I've been able to achieve on a 100% charge, even when my range shows 160-170km – driving very conservatively, in "ECO" mode, air-con off, etc etc – is about 135km.

Steep and/or long hills knock the range around dramatically – and if you know the northern beaches of Sydney, you'll know that it is ALL hills. I live not far above sea level – to get anywhere means an uphill to start off with. Heading north-west from my place is a long (7.5km) uphill, ranging from moderate to quite steep. That 7.5km costs me up to 40km range on the guessometer!

Sure, you get *some* back with downhill regeneration – but I would be extremely surprised to find anyone in Sydney who gets anything like 170km range on a charge. And remember, you have to be able to charge at the opposite end to come home again. So unless you're staying long enough (overnight?) AND can plug in to charge, the distance you can travel away is effectively halved!

As an example, in February and March I made a few trips from Narrabeen to Umina, a distance of 85km. That trip encounters some not inconsiderable hills (both directions start with a long uphill) and I must admit to some range anxiety.

With a 100% charge to start, I had between 15 and 25km range left – and that's limiting my speed to 100km/h on the M1 motorway. I had previously noted the battery drain difference between 100km/h and 110km/h (a *lot* more than 10%!) so was not willing to risk it.

There's an on-dash active range map which suggests I could reach Newcastle on one charge. Oh yeah? I'd like to see that!

Lastly, I'm often asked about battery longevity – that is, how long the on-board 360V Li-ion battery will last before it must be replaced. Nissan guarantee 80% capacity after 10 years and some reports I've seen suggest they expect 15 years+.

The problem is, of course, that we're only a third of the way through that 15 years (since introduction), so no-one really knows. But apart from a few horror stories (manufacturing faults?), battery longevity is largely proving to be at least as good as projected.

All of this, though, makes Tesla CEO Elon Musk's latest statements about long life (>15 years) and long range batteries (300 and even 500+ ***miles***) sound rather exciting, especially if (as has been hinted) the technology that Tesla has been developing will be made available to other manufacturers. Like Nissan? SC

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KCS has extended their successful TraceME product line with an advanced module, targeted for worldwide mobility in the Internet of Things era. The latest development of the TraceME GPS/GPRS Track and Trace module will combine the RF location based positioning solution with the LoRa™ technology. This combination offers 'smart objects' being even smarter, since LoRa™ enables long range, battery friendly communication in a wide variety of (M2M) applications. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon™ provides easy integration with existing wireless networks and mobile apps. Other variants in the high/mid-range and budget-line will follow soon.

ANTI-THEFT module based on RF

KCS TraceME product line offers an intelligent location based positioning solution for indoor and anti-theft applications.The solution is based on RF with an Intelligent algorithm of measuring the propagation time of transmitted (proprietary protocol) signals. Unique features are: minimum size (46x21x6.5mm), weight (7 grams for fully equipped PCB) and a standby battery lifespan of more than 10 years. Listen before talk' algorithm makes it practically impossible to locate the module, which secures the valuable vehicle or asset. Supporting GPRS/SMS and optional 3G, Wi-Fi, Bluetooth LE, ANT/ANT+ and iBeacon provide easy integration with existing wireless networks and mobile apps.

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TESLA'S POWERWALL: A Game Changer?

Purely by co-incidence, as we were reviewing and writing about the Tesla Model S, internet whispers started appearing about a secret new product being worked on by Tesla. Then came the official word: CEO Elon Musk would be hosting a major press launch on April 30 to reveal the big secret.

By Ross Tester

By the time Elon Musk took to the stage, the whispers had become a roar – Tesla was about to release battery backup systems for home and industry. It was a natural progression from their work on the lithium-ion battery packs they'd developed for their electric vehicles but the detail was all that was left to reveal.

As well as the "live" press launch, it was also beamed to the world as a webinar, so wherever you were, you could see the same message. And the message was pretty "cool", at least as far as Tesla were concerned.

For far too long, we've been saddled with lead-acid batteries as the main storage for, particularly, solar (PV) power systems. Lithium-ion batteries were simply too expensive.

Of course, most installations (at least here in Australia) don't have any storage; they've been grid-based systems which fed any excess power back into the electric power distribution grid.

Those who got in early have been blessed with very high value feed-in

Tesla CEO Elon Musk launching the PowerWall and PowerPack (for utilities), April 30 2015.

One of Tesla's 10kWh PowerWalls. Inside is 350-450V of lithium-ion cells and a DC/DC converter. It's about 1300mm high, 860mm across, 180mm deep and weighs 100kg.

rewards – as much as 66c per kWh. Those heady days have long gone but even today, you can put a solar power system in and reduce your electricity charges.

But Tesla's system is rather different to that. It is intended for either stand-alone (ie, not grid-connected) systems or hybrid systems, where there is battery backup as well as grid tie-in.

Musk reasoned that everything about electricity production, usage and charges were out of step – the highest usage was in the morning, after most people had gone to work, and in the evening/night, after most people had come home. Either way, solar generation is minimal in the early morning and zero in the night, when you needed it most. You pay top dollar for power at these times too.

What if the generation and storage of electricity could be "time shifted" - generate the power during the day when the sun was shining and use it during the peak periods mentioned above. All you would need would be a storage system capable of doing so!

OK, that's a bit of an over-simplification but you get the idea!

Lead-acid battery disadvantages

One of the major reasons for not using lead-acid batteries for storing electricity is the cost. Deep-cycle storage batteries are not cheap.

Moreover, they need a lot of maintenance; they emit dangerous hydrogen gas when being charged; they sometimes leak (and their electrolyte, acid, is nasty stuff); they're pretty temperamental about amount and depth of discharge; they don't like being overcharged . . . and to top it all off, their life span can be pretty short (3-5 years is about average, 10 years exceptional; indeed, most deep cycle batteries only have a 2 year guarantee).

Finally, when they have reached the end of their life, disposal is not as easy. They can't be used in landfill, they can't be destroyed and even many recycling centres that used to take plenty of lead-acid car batteries are becoming a bit reluctant to take them.

Small wonder that most people with solar panels on their roofs stayed well-enough away from lead-acid batteries.

Lithium-ion battery advantages

While there are some parameters that need monitoring, for the most part lithium-ion batteries don't suffer the disadvantages of lead-acids. They don't need much maintenance at all, they're much happier about charging and discharging (mainly because each cell is monitored and if necessary, equalised with other cells), they have a long lifespan (10 years would be minimum, possibly a lot more) and they don't contain volatile materials so can even be disposed of in landfill. Or, as we reported in the earlier Tesla S85 story, they are looking at recycling as much as 90% of each cell in the future.

Tesla's PowerWall

Two (related) products were announced on April 30, the PowerWall and the Tesla PowerPack. The latter is intended for large-scale applications. The first will start shipping shortly (within a couple of months) – in fact, Tesla Energy started taking orders immediately on announcement. (However the latest news [May 10] is that production through to the middle of 2016 is sold out – over 38,000 reservations had been received in that time)!

What's in it?

The basic PowerWall comes in 10kWh "weekly cycle" and 7kWh, "daily cycle" models. Each contains enough lithium-ion cells to achieve a 350-450V supply. The PowerWall is designed to attach to a wall, inside or outside. Overall size of a single PowerWall unit is 1300mm high, 860mm wide and 180mm deep and weight is 100kg.

Note that there is no DC-to-AC inverter built in but it does have a DC-DC converter, which means it should be compatible with solar panels (which generate DC).

Up to nine PowerWalls can be interconnected to satisfy virtually all domestic demand.

And the cost?

The daily cyle (7kWh) PowerWall will sell in the US for $3000; the 10kWh weekly cycle for $3500.

Let's look at the more expensive one: in Australia, at current exchange rates and with GST that will probably sell for around $5000.

For that, you get a ten year guarantee and minimal maintenance.

Try buying, say, a 350V deep cycle lead-acid battery pack with anything like a 10kWh rating. Because you can only safely cycle down to, say, 40% you'll need around 16kWh to be safe. At the moment, you're looking at between $20,000 and $25,000. Invariably, that only gets you a 2-3 year guarantee and it also gets you all the trials and tribulations that go with large lead-acid battery installations, not the least of which is a total replacement after perhaps five years.

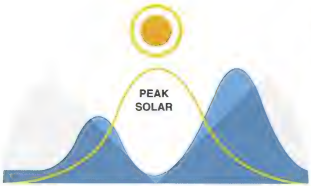
Of course, prices are dropping . . . and Tesla's PowerWall will have a lot to do with that!

Other power sources

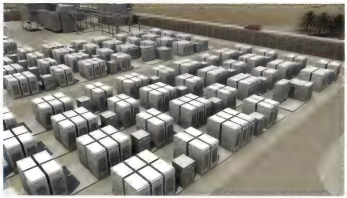
One of the main reasons that Tesla's PowerWall is likely to be a game-changer is that for the first time, it makes economic time-shifting power demands.

Solar panels are not the only means of charging batteries –wind and small-scale hydro are often mentioned.

But the one which is often forgotten



The average home uses more electricity in the morning and evening than during the day when solar energy is highest. Tesla's Powerwall is designed to smooth out these curves.



Thinking big: Tesla also have plans for power generators and distributors to use very much larger battery banks to smooth out their own peak and trough cycles.

is the power grid itself. During peak periods, power charges are high. At "shoulder" times they're lower and during off-peak times they can be quite low.

Why not use cheap off-peak power to charge the batteries and either use it instead of expensive peak power. Or if you can get a reasonable feed-in tariff, sell it back to the power companies during peak times?

We can already hear the screams: "you can't get enough feed in tariff any more to make it worthwhile."

Oh yeah? Go for a walk with Dr Google – you might be surprised to find that there are now companies in Australia (not the power companies!) who will buy stored power from you at much higher prices than the power companies offer. They on-sell it to match peak demand and therefore peak $$$ – and reward you with the proceeds (less their commission).

If you think we're talking cents per kWh, think again. It can be $/kWh!

It is for all these reasons that we believe Tesla, and their $5000 lithium-ion battery, will be a game changer.

Whether you're using it to go completely off grid (now very much cheaper than it was), or putting in a hybrid system; whether you are looking at solar power or simply time-shifting cheap off-peak power into peak times, it's a whole new ball game.

And the best part? The game has only just begun!

For more information, visit www.tesla-energy.com – or Google "Tesla Powerwall" and "Tesla Powerpack" SC

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Artificial vision is becoming a reality

The BIONIC EYE

Vision is our most important sense, accounting for about 80% of information received by our brains. The loss of vision can therefore have a dramatic effect on a person, especially if they lose it through accident or disease. Now there is promising research on how to restore a basic sense of vision.

Part 1 - By Dr David Maddison

As with the well-established cochlear implant ("bionic ear", of which Australia is a world leader) which can restore a sense of hearing, there is now active research on how to restore a basic sense of vision, using an implantable visual prosthesis or "bionic eye".

So as not to give false expectations, artificial vision does not provide a visual experience like natural vision.

Bionic vision is a popular theme in science fiction, two notable examples being Colonel Steve Austin in *"The Six Million Dollar Man"* and Lieutenant Commander Geordi La Forge in *"Star Trek: The Next Generation"* (see box).

Like many other themes from science fiction, bionic vision is also becoming a reality – even if the science is in its infancy.

Apart from implants to restore a sense of vision there are also non-implanted prosthetic devices that work on the principle of *sensory substitution* whereby the sense of sight is converted into an alternative sense such as touch or sound and these will also be discussed.

Finally, a method of human vision for the blind involving no hardware but just skill is also presented.

How the eye works

In nature, ten different types of eye layout can be found. The eye layout found in humans and vertebrate animals, cephalopods (squid and octopuses) and some spiders most resembles a traditional camera.

In this type of eye, called a camera-type eye, light enters through the cornea which acts as a window and also refracts light like a meniscus lens, contributing two thirds of the optical power of the eye.

It then passes through the iris which alters its diameter to adjust the amount of light entering the eye, then through the adjustable lens which adjusts its focal length to focus objects from different distances and then projects an image onto the light sensitive retina at the back of the eye.

The eye lens also has a graded optical index (like modern optical fibres) for maximum efficiency

and also contributes one third of the optical power of the eye.

The retina

Being the light-sensitive part of the eye, the retina is also the part which is often diseased or damaged, leading to a severe vision deficit or blindness.

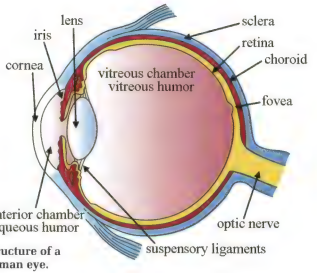
The retina is comprised of a number of layers containing neurons which communicate with each other via synapses. A neuron is an electrically active cell that can receive inputs, process them and produce an output. An output signal from a neuron is transmitted to other cells across a synapse (see SILICON CHIP, *"Interfacing to the Brain"*, January 2015).

Some neurons are specialised as photoreceptor cells which are sensitive to light. The two main types of these specialised neurons are rods and cones. Rods are sensitive in low light and provide monochrome vision while cone cells are sensitive to colour and work in bright light. There are about 100,000,000 rods and 5,000,000 cone cells.

Visual signals from the rods and cones are processed by other neurons in the retina to reduce the amount of visual data that has to be sent back to the brain.

One of the ten layers of the retina is the ganglion cell layer. The rods and cones are connected to this layer via another type of neuron. The ganglion cells are a type of neuron that has a very long axon that extends from the eye back into the brain to form the optic nerve, optic chiasm and optic tract (see diagram and text below). It is the ganglion cells that carry information from the retina into the brain. There are about 1,500,000 ganglion cells.

The axon is the part of the cell body that connects to other neurons and from which information leaves (See the above article from SILICON CHIP, January 2015, for discussion of neurons and axons.)

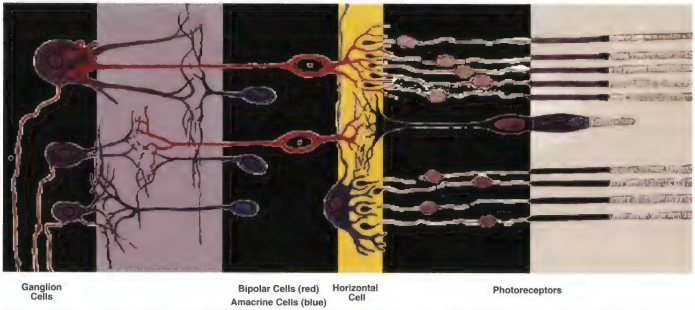


Structure of a human eye.

It is the rods and the cones, the photoreceptor cells which are most often damaged by disease while the underlying layers which carry visual information back to the brain such as the ganglion cell layer are usually left intact. These remaining layers can be used to introduce visual information to the brain via a prosthetic retinal implant in one type of bionic eye.

Note from above there are around 105,000,000 rod and cone cells generating information and only 1,500,000 ganglion cells to convey that information back to the brain. This lack of a one to one correspondence is suggestive of the amount of data processing that has occurred in the eye itself.

To complicate matters further, the surface of the retina is not uniform in its properties or photoreceptor density.



Simplified cross section of a human retina. Counter-intuitively, light enters on the left of the diagram which is the inner part of the eye. This is the ganglion cell layer which is the connecting circuitry that takes information back to the brain. The light then travels toward the photoreceptors (rods and cones) which are at the outer part of the eye where light is converted to signals which are transmitted to the ganglion cells through several layers. This is the opposite arrangement to an imaging chip in a camera whereby the light sensitive elements are at the light receiving side and the connecting circuitry is beneath that. In the various layers, points of light from the rods and cones are processed to identify features such as movement, simple shapes, edges and bright points surrounded by dark points before the information is sent back to the brain for further processing. Image credit: "Retina layers1". Licensed under CC BY-SA 3.0 via Wikipedia – http://en.wikipedia.org/wiki/File:Retina_layers1.gif#/media/File:Retina_layers1.gif

Image from the retina, showing higher resolution image from fovea, the small part of the retina responsible for the sharpest vision. The brain fills in for the rest of the retina which produces a less sharp image but is not noticed under normal circumstances. Frame grab from https://youtu.be/4I5Q3UXkGd0

The fovea is a small part of the retina, about 1.5mm in diameter, that is responsible for sharp vision, with a very high concentration of cone cells. The fovea is connected to about half of the nerve fibres in the optic nerve while the rest of the retina connects to the other half.

The fovea represents only about 1% of the retinal surface but uses 50% of the visual cortex, showing its great importance in sight. Its visual field is small, equivalent to about two thumbnails at arm's length so to get a sharp image of an object the eye has to scan back and forth to build up an image.

The fovea also only has cone cells so is not sensitive at night.

The blind spot

You'll probably remember those biology lessons at school where a card is moved in and out from one eye and at some point an "X" on the card disappears. That is caused by the blind spot, an area where the optic nerve passes through the retina and no photoreceptors exist. (*See* www.education.com/science-fair/article/eye-retinal-blind-spot/).

Normally the brain makes up for the lack of receptors in that area so its effect is not noticed.

The shape and size of the eye are also important considerations for bionic prostheses. The eye is not spherical but it is roughly the shape of two hemispherical sections joined together.

Also, despite people coming in all shapes and sizes, the size of the eye between different individuals is remarkably uniform and is around 24mm front to back varying by only up to 2mm. This means perhaps only one size of visual prosthetic device that goes in the eye (or replaces it) will ever need to be manufactured.

It has been estimated that the data bandwidth of the human eye is 8.75Mbits/s. The neurons could fire much faster giving a much higher speed but there is a trade-off of speed and energy and data processing efficiency.

A question often asked and which is important for comparing natural vision to a bionic eye is what is the resolution of the human eye. It is not simple to answer that question because unlike a still camera, the eye does not record a static image.

The eye records a video stream of sorts but the neural hardware of the eye and brain extract and see only that information that is relevant, somewhat like highly compressed video data where only changes in a picture are transmitted.

The question is further complicated by the fact that the eye and body move and the brain assembles these images from different viewpoints into a type of composite image that has more information than the number of photosensitive cells in the eye would suggest (like taking a number of still images panning across a scene and assembling them into a larger image).

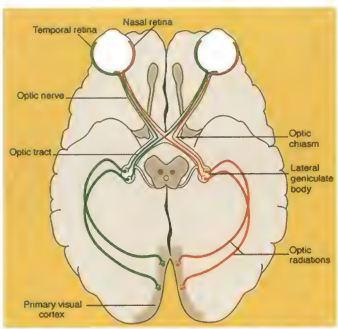
Taking all of the above into account, one conservative estimate made by Roger Clark (www.clarkvision.com/articles/human-eye/) for the resolution of the human eye is 576 megapixels to view a scene of 120° x 120° but the real field of view is even larger than this.

Other estimates are that what we see is equivalent to the high resolution area of the fovea having a 7-megapixel resolution and the rest of the eye having a resolution of one megapixels. These issues are discussed in the video "*What Is The Resolution Of The Eye?*" https://youtu.be/4I5Q3UXkGd0

Structure of the visual system

The visual system of an advanced organism such as a mammal usually consists of the following principal components:

- the eye and its main component containing photo receptors, the retina;
- the optic nerve for relaying information from the retina to the brain;
- the optic chiasm which causes signals from the optic nerves to partially cross to allow the visual cortex to receive a complete visual field from both eyes and then combine them for stereoscopic vision;
- the lateral geniculate body which has multiple functions and receives information from the retina via the optic nerve and optic chiasm and also processes that data before passing it on via the optic radiations to the visual cortex where the sense of vision is generated.



Visual system of a human. Note how the visual fields represented by the green and orange colours start in the retina, partially cross at the optic chiasm and are finally mapped onto the visual cortex.

Even though the eye has the same basic optical elements as a camera as described above, it is far more than a camera and a lot of processing of visual data is done inside the retina itself with numerous different types of neurons involved as well as processing of visual data done elsewhere in the brain.

Function of the bionic eye

A bionic eye works by stimulating some part of the visual system in order to generate a sense of vision in cases where the eye or other components of the visual system are absent, diseased or defective. As the nervous system and brain use electric currents to convey information, electrical stimulation is the obvious choice to stimulate the visual system.

Historical background

The use of an electrical current to stimulate vision was first undertaken in 1755 by Frenchman Charles LeRoy who passed electricity through the eye of a blind man and this resulted in the him perceiving the sensation of light.

Following that was the discovery of electrical activity in animal brains in 1875 but this involved exposing their brains which was a procedure not amenable to human experiments. The first EEG or electroencephalograph to record these brainwaves was taken of a dog in 1914 by Hans Berger who invented that machine.

At the end of WWI in 1918 the first observations were made in Germany that electrical stimulation of the surface of the visual cortex in patients undergoing neurosurgical procedures under local anaesthesia resulted in the patient seeing dots of light or "phosphenes".

In 1924 Hans Berger recorded the first electrical activity from a human brain with scalp electrodes, a remarkable achievement at the time given the small voltages involved and the recording instruments of the time.

Otfrid Foerster in 1929 investigated electrical stimulation of the occipital lobe (where the visual cortex is located) and reported that people could see a dot of light. The idea that many sites could be simultaneously stimulated to provide vision was postulated by W. Krieg in 1953.

Of course, the complex electronics required to drive multiple electrode arrays in a portable package would not be available from some decades not to mention suitable implant materials.

The measurement of electrical activity in the brain and its connection to visual processes was thus established leading to the possibility of artificial vision for the blind as well as a large array of other possibilities for interfacing the human brain to machines; see *Interfacing to the Brain*, Silicon Chip, January 2015.

Eye diseases and conditions to be treated

Two common causes or visual impairment or blindness are among conditions sought to be treated with bionic vision:

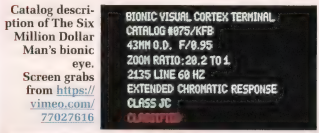
- **Age-related macular degeneration** is a condition resulting in the loss of central vision leading to the loss of abilities such as reading, facial recognition, reading clocks and street signs. Peripheral vision is maintained although the area of central vision loss gets larger with time. The fovea, responsible for high resolution vision, is part of the macula.
- **Retinitis pigmentosa** is a degenerative condition of the

The bionic eye in science fiction

The Six Million Dollar Man was a 1973 TV series which featured a bionic man, Colonel Steve Austin, with a bionic eye.

What was portrayed as a fantasy 42 years ago, appears to be within the grasp of current or foreseeable technology.

Also, Star Trek: The Next Generation featured Lieutenant Commander Geordi La Forge with a bionic eye.

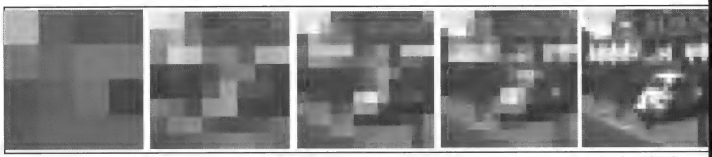


Catalog description of The Six Million Dollar Man's bionic eye. Screen grabs from https://vimeo.com/77027616

CAD diagram, very good for 1973 vintage, showing The Six Million Dollar Man's bionic eye and interface circuitry to the visual cortex.

The bionic eye of The Six Million Dollar Man.

Lieutenant Commander Geordi La Forge from Star Trek: The Next Generation with his VISOR device (Visual Instrument and Sensory Organ Replacement) that can see most of the electromagnetic spectrum. It is interfaced to his brain via the optic nerves. The technology for this type of device seems a little further into the future than that of The Six Million Dollar Man's device.



Representation of a parked car at different resolutions. In order of increasing resolution these images are 16 (4x4), 64 (8x8), 144 (12x12), 256 (16x16), 1024 (32x32), 4096 (64x64) and 16384 (128x128) pixels. Note that these images indicate the amount of information that might be conveyed at a particular resolution, not what a person would necessarily see. These images are also grey scale. Retinal and cortical prostheses currently display phosphenes (pixels) that are either off or on with no shades or colours. Also, in a current retinal or cortical implant, individual pixels will have space between them. The sensory substitution device, The vOICe does have 16 shades of "loudness". (Courtesy Dr Peter Meijer, The vOICe.)

eye due to the loss of photoreceptor cells and an increasing loss of peripheral vision resulting in tunnel vision and eventual blindness.

In both the above cases, the photoreceptor cells have died but the neural pathway to the brain remains intact so in principle, this pathway can be activated with a retinal implant that stimulates the remaining pathway.

Vision loss due to missing eyes or optic nerve damage can be treated by stimulation of areas such as the lateral geniculate body or the visual cortex within the brain.

Ways of interfacing a bionic eye to the brain

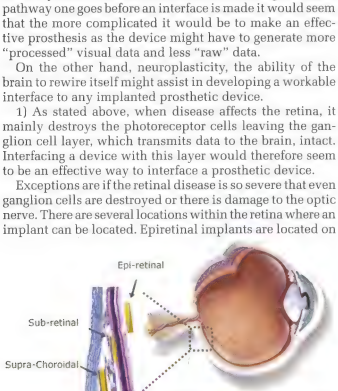
Consideration of the anatomy of the human visual system as described above suggests four ways a bionic eye can interface to the brain.

An account needs to be made of the fact that the retina itself processes information and so does the lateral geniculate body and the visual cortex. The further along the visual pathway one goes before an interface is made it would seem that the more complicated it would be to make an effective prosthesis as the device might have to generate more "processed" visual data and less "raw" data.

On the other hand, neuroplasticity, the ability of the brain to rewire itself might assist in developing a workable interface to any implanted prosthetic device.

1) As stated above, when disease affects the retina, it mainly destroys the photoreceptor cells leaving the ganglion cell layer, which transmits data to the brain, intact. Interfacing a device with this layer would therefore seem to be an effective way to interface a prosthetic device.

Exceptions are if the retinal disease is so severe that even ganglion cells are destroyed or there is damage to the optic nerve. There are several locations within the retina where an implant can be located. Epiretinal implants are located on the inner surface of retina, subretinal implants are located behind the retina and suprachoroidal implants are located above the choroid and behind the retina.



The three possible locations of retinal implants. (Courtesy Bionic Vision Australia.)

2) Beyond the ganglion layer of the retina, there is a possibility of interfacing with the optic nerve although this involves challenges due to accessibility issues and also interfacing to a thin nerve with around about 1,000,000 nerve fibres.

One such example is the Microsystem-based Visual Prosthesis (MIVP) which consists of a spiral cuff electrode wrapped around the optic nerve. Unlike retinal or cortical implants which produce monochrome phosphenes, coloured phosphenes have been reported in this stimulation method. Test subjects have also been able to locate and discriminate between objects.

3) Interfacing to structures such as the lateral geniculate body deep within the brain is possibly risky and complicated although this is a site being researched for interfacing a bionic eye.

At the lateral geniculate body the visual data has not yet been so extensively processed that it has become too complicated to interpret and map. At this point a visual scene is mapped onto the brain tissue in a relatively simple way and bears a correspondence to the scene being observed.

It has been estimated that the maximum resolution of an electrode array implanted at the location would be 40x40 per side.

4) The final interfacing possibility is the primary visual cortex of the brain (V1) which is close to the surface of the brain and relatively accessible. This area is specialised for processing information about stationary and moving objects and pattern recognition.

The visual image of the retina is mapped onto V1 and a large portion of that retinal map corresponds to the fovea. Stimulation of this region of the brain enables a person to generate points of light (phosphenes) which can be used to generate a form of vision as has already been shown in experiments.

A problem with using V1 as an interface is that the mapping of the retina is not linear so that, say, a square electrode area would not correspond to the same shape in the visual field.

The first experiments in artificial vision

In the early 1960s Giles Brindley and W.S. Lewin in the UK started researching artificial vision and this resulted

in 1968 of the implant of 80 electrodes into the visual cortex of a blind person. The experiment was a success and the subject was able to identify letters and patterns in the phosphenes that were generated by electrical stimulation of the 80 electrodes and the research was published in a classic scientific paper in 1969.

This lead to a major international conference at the University of Chicago which was to establish future directions for this work.

Giles Brindley's work inspired numerous similar research projects in the 1970s with the main objective of assisting the blind to read with the low resolution image provided by 80 or so electrodes. Many experiments were done stimulating the visual cortices of volunteers who were having neurosurgery for other reasons as well as volunteers having electrode implants.

It soon became less important to assist the blind to read due to the development of talking books recorded on cassette tape and the emphasis became that of assisting the blind to navigate in their environment.

This required a portable electronic package to do the visual processing required to create a usable image on the implanted electrodes but at the time creating a small portable processing unit was not possible with the electronics available; this technology would not be available until the 1990s.

Jeremiah Teehan is credited by the Guinness Book of Records as the first person to have an artificial eye. The device was developed by the late William Dobelle and others.

The record is dated 17th January 2000 and he had 68 platinum electrodes implanted on the surface of the visual cortex of his brain, although only 20 worked effectively and gave a narrow field of view, and he wore glasses containing a camera and an ultrasonic rangefinder as well as a 4.5kg visual processor unit on a shoulder strap.

He had vision the equivalent of a severely short-sighted person with 20/400 vision and saw the outline of objects and letters. Unfortunately the implant deteriorated and had to be removed. The support electronics could be substantially miniaturised today.

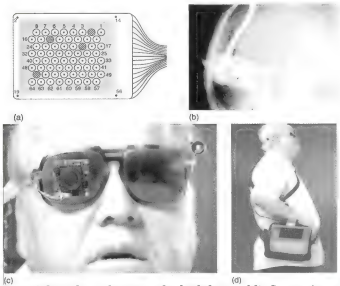
Another of William Dobelle's patients, Jens Naumann, wrote an account of his experience with artificial vision called *"Search for Paradise: A Patient's Account of the Artificial Vision Experiment"*. Also, see the video *"Jens Naumann: Artificial Vision"* https://youtu.be/JWMYW-SkURI

His implant also deteriorated and he is again blind.

Also see pictures of his implant at www.jensnaumann.green-first.com/gallery.shtml

Early experiments with bionic vision as described above involved electrode arrays on the visual cortex but one alternative approach was to stimulate the retina itself. The first clinical trial of a 16 electrode retinal implant was made in 2002 by Second Sight Medical Products: www.2-sight.com

What was once only a dream of restoring vision in the blind has now progressed to a reality today with people actually using visual prostheses that give them some visual perception of the world.



Jeremiah Teehan, the man who had the world's first artificial vision system. Unfortunately, the implant deteriorated and had to be removed. The cortical implant is shown in image (a) and an x-ray of the implant in (b) the glasses/camera combination is shown in (c) and the processing unit in (d). (From "Organic Bionics", Wiley-VCH, 2012).

Desired resolution

It should be noted that the objective of bionic eye research is not to provide the equivalent of natural vision as this is way beyond any technology currently available, but as with the cochlear implant, it is designed to give a workable, usable replacement for a lost or missing sense which may have much less fidelity than the natural equivalent but can still be of tremendous help to the person using the technology.

An important question to answer is: what resolution of image is usable for a blind person to navigate about the world, say to walk to shops or catch public transport and read signs and food labels? This question applies equally to either a bionic eye or a sensory substitution device.

It has been demonstrated in studies that a resolution of 32x32 pixels or 1024 pixels is more than enough to get meaningful and usable images. At lower resolutions a 4x4 array will provide motion detection capability, an approximately 100 electrode array will provide a navigational capability and an approximately 1,000 electrode array will provide facial and letter recognition.

A video showing different resolutions of retinal implant can be seen at https://youtu.be/4gaBAIzAn-M *[Project Xense Retinal Implant Simulation]*. Note the separation between individual pixels. SC

NEXT MONTH:

In the final part of this mini series, we will look at some of the amazing advances being made here in Australia in the quest for the perfect Bionic Eye.

SILICON CHIP ONLINESHOP
.com.au/shop

Looking for a specialised component to build that latest and greatest *SILICON CHIP* project? Maybe it's the PCB you're after. Or a pre-programmed micro. Or some other hard-to-get "bit". The chances are they are available direct from the *SILICON CHIP* ONLINESHOP.

As a service to readers, *SILICON CHIP* has established the ONLINESHOP. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts such as PCBs & micros.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even IF stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, regardless of how many boards or micros you order! (Australia only; overseas clients – email us for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

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VISA MasterCard PayPal

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Via EMAIL (24 hours, 7 days)
email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details

Via MAIL (24 hours, 7 days)
PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details

Via PHONE (9am-5pm, Mon-Fri)
Call (02) 9939 3295 (INT 612 9939 3295) – have your order ready, including contact and credit card details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *SILICON CHIP ONLINESHOP* stocks microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13)
PIC16F1507-I/P	IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *2 chips – $15 pair* (Aug13) Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jan13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14). Remote Mains Timer (Nov14)
PIC16LF88-I/P	Garbage Reminder (Jan13), Belbird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul 14)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jan15) – *also includes* **FREE** *47µF tantalum capacitor*
PIC32MX170F256B-I/SP	Low Frequency Distortion Analyser (Apr15). **Bad Vibes (June 15)**
PIC32MX170F256D-50I/PT	44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14). Digital Effects Unit (Oct14)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10). Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-May 13)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)
ATMega48-20AU	Stereo DAC (Sep-Nov09), RGB LED Strip Driver [-**20AU chip**] (May14)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, SHORT-FORM KITS, ETC

P&P – $10 Per order#

NEW: BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC *(Jun 15)* $2.50

BALANCED INPUT ATTENUATOR - all SMD components inc.12 NE5532D ICs, 8 SMD diodes. SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole) *(May 15)* **$65.00**

APPLIANCE INSULATION TESTER - 600V logic-level Mosfet, 5 x HV resistors: *(Apr15)* **$10.00**

ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors: *(Jan15)* **$40.00**

CDI – Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor: *(Dec 14)* **$40.00**

CURRAWONG AMPLIFIER Hard-to-get parts pack: LM1084IT-ADJ, KSS6030, 3 x STX0560, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors *(Dec 14)* **$50.00**

ONE-CHIP AMPLIFIER - All SMD parts *(Nov 14)* **$15.00**

DIGITAL EFFECTS UNIT WM8371 DAC IC & SMD Capacitors *[Same components also suit Stereo Echo & Reverb, Feb14 & Dual Channel Audio Delay Nov 14]* *(Oct14)* **$25.00**

ADB038ARZ Video Amplifier ICs (SMD)
For Active Differential Probe. (Pack of 3) *(Sept 14)* **$12.50**

44-PIN MICROMITE Complete kit inc PCB, micro etc *(Aug14)* **$35.00**

MAINS FAN SPEED CONTROLLER - AOT11N60L 600V Mosfet *(May14)* **$5.00**

RGB LED STRIP DRIVER - all SMD parts and BS0150N03 Mosfets, does not include micro (see above) nor parts listed as "optional" *(May14)* **$20.00**

HYBRID BENCH SUPPLY- all SMD parts, 3 x BOM8560S & L2/L3 *(May 14)* **$45.00**

USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC *(Apr14)* **$7.50**

NICAD/NIMH BURP CHARGER *(Mar14)* **$7.50**
1 SPD15P10 P-channel logic Mosfet & 1 IPP230N06L3 N-channel logic Mosfet

10A 230V AC MOTOR SPEED CONTROLLER *(Feb14)* **$45.00**
40A IGBT, 30A Fast Recovery Diode, PR2125 Driver and NTC Thermistor

GPS Tracker MCP1630I SMD regulator IC and 15µH inductor *(Nov13)* **$5.00**

SMD parts for SiDRADIO *(Oct13)* **$20.00**
Same as LF-UF Upconverter parts but includes 5V relay and BF998 dual-gate Mosfet.

RF Probe All SMD parts *(Aug13)* **$5.00**

LF-HF Up-converter Omron G5V-1 5V SPDT-5V relay *(Jun13)* **$2.00**

"LUMP IN COAX" MINI MIXER SMD parts kit: *(Jun13)* **$20.00**
Includes: 2 x OPA4348AID, 1 x BQ2057CSN, 2 x DMP2215L, 1 x BAT54S, 1 x 0.22Ω shunt.

LF-HF UP-CONVERTER SMD parts kit: *(Jun13)* **$15.00**
Includes: FXO-HC536R-125 and SA602AD and all SMD passive components

CLASSIC DAC Semi kit – Includes three hand-to-get SMD ICs: *(Feb-May13)* **$45.00**
CS8416-CZZ, CS4398-CZZ and PLL1708DBQ plus an accurate 27MHz crystal and ten 3mm blue LEDs with diffused lenses

ISL9V5036P3 IGBT Used in high energy ignition and Jacob's Ladder *(Nov/Dec12, Feb13)* **$10.00**

2.5GHz Frequency Counter *(Dec12/Jan13)*
LED Kit: 3 x 4-digit blue LED displays **$15.00**
MMC & Choke Kit: ERA-2SM+ Wideband MMC and ADCH-80+ Wideband Choke **$15.00**

LOOKING FOR TECHNICAL BOOKS? YOU'LL FIND THE COMPLETE LISTING OF ALL BOOKS AVAILABLE IN THE SILICON CHIP ONLINE BOOKSTORE – ON THE "BOOKS & DVDs" PAGES AT SILICONCHIP.COM.AU/SHOP 06/15

*All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. # P&P prices are within Australia. Q'eaes? Please email for a quote

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit.* If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
COMPACT 12V 20W STEREO AMPLIFIER	MAY 2010	01104101	$7.50
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$10.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	$10.00
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$15.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$20.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$20.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$20.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$20.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$10.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$10.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$20.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$20.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04109073	$10.00
HEARING LOOP RECEIVER/NECK COUPLER	SEP 2011	01209101	$10.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$25.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$25.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$30.00
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$20.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01121111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01121112/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201122/1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101212/2	$25 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	04102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102122	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	11105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	23109121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110122	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	11105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10-CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IP00 CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp (Sept'11))	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	/01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above (Nov 2012/May 2013))			
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender Mk2	JAN 2014	01112131	$15.00
LI'l Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	11102141	$12.50
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141b	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR OSCILLOSCOPE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015		$5.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$10.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$5.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$30.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00

NEW THIS MONTH

SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7.50

By Nicholas Vinen

The Bad Vibes Infrasound Snooper

Back in March 2013 we published the Infrasound Detector for low frequency measurements. Now you can "listen" to low frequency vibrations with our Infrasound Snooper. It frequency shifts and amplitude modulates a frequency range of about 1Hz to 20Hz by about five or six octaves so that you can listen directly to wind turbines or elephants, crocodiles and other animals that communicate with infrasound.

OUR INFRASOUND SNOOPER uses Digital Signal Processing (DSP) techniques in a PIC32MX170 microcontroller, an electret microphone, a DAC chip, a TL074 quad op amp and very little else, to drive a pair of headphones.

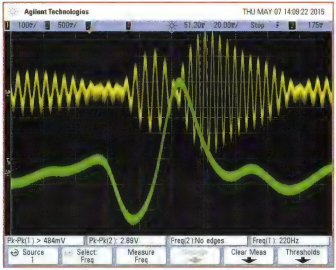
High levels of infrasound can have a negative impact on your health but you might not even know when you are being exposed to low frequency vibrations unless they excite harmonics by rattling window panes and similar, because they're otherwise inaudible.

In January this year, a study by acoustics expert Steven Cooper of Bridgewater Acoustics attracted a great deal of controversy over its findings which support the notion that infrasound from wind turbines can cause negative health impacts on people some distance away.

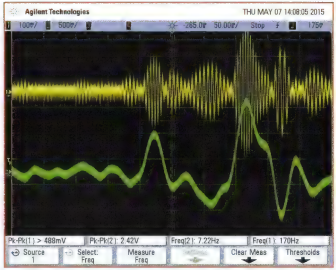
At the SILICON CHIP offices, some of our staff recently experienced ill effects, including headaches and nausea, when a ground compacting machine was operating on a nearby building site. It evidently set up all sorts of standing waves in our building, as it moved around the construction site. Some "nodes" in our building were quite unpleasant places to be.

So if you are living or working near potential sources of infrasound and are suffering from some of the potential symptoms, our Infrasound Snooper can certainly help.

Our Infrasound Detector (SILICON CHIP, March 2013) allows you to measure the amplitude and frequency of infrasonic sound waves but the results can be somewhat difficult to interpret since you cannot hear the phenomenon. The Infrasound Snooper lets you assess the amplitude and frequency of



Scope1: amplified infrasound output from IC2c (green) and the modulated signal to the headphones (yellow) for a low-frequency impulse of about 10Hz. The mode is AM+FM with low-frequency boost and you can see the output frequency shifting for the positive/negative infrasound signal as well as the delay from the low-frequency boosting filter.



Scope2: a similar impulse at a longer timebase than Scope1 (50ms/div rather than 20ms/div). The mode is AM+FM without low-frequency boost and thus the output waveform modulation corresponds very closely to the green input signal excursions. As before, positive excursions produce higher modulated frequencies than negative excursions.

the waves but importantly, you can also hear the details – whether they are short, repetitive bursts, continuous waves or somewhere in between.

Our Infrasound Snooper is housed in a small plastic box and uses a double-sided PCB (code 04104151) measuring 104 x 60.5mm. An electret microphone is mounted at one end of the case and a rotary switch on the lid offers a number of different listening modes.

Circuit description

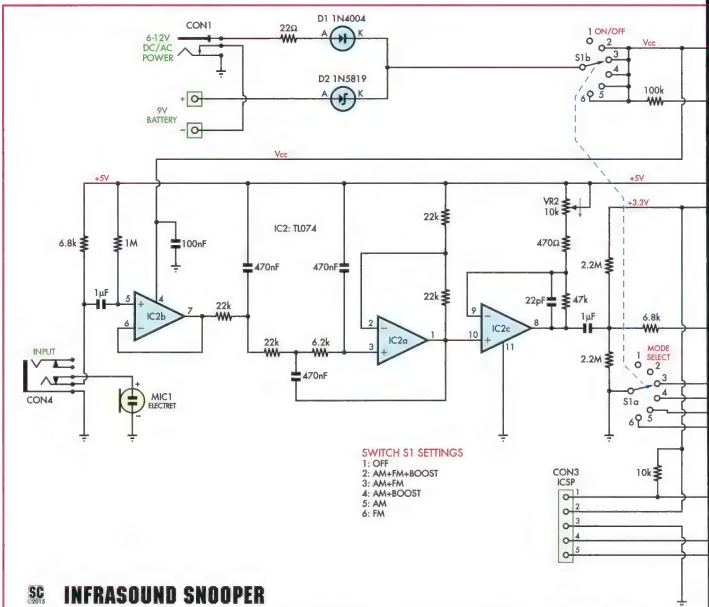
Fig.1 shows the circuit details. Infrasonic sound waves are sensed with the electret microphone (MIC1) or an external microphone plugged into CON4. A 6.8kΩ pull-up resistor from the 5V regulated rail provides the electret's operating current.

The electret signal is AC-coupled via a 1µF capacitor to the non-inverting input of op amp IC2b, one section of a TL074 quad JFET-input op amp. In conjunction with the 1MΩ resistor, this capacitor forms a low pass filter with a -3dB corner frequency at 0.2Hz. Thus signals above 0.5Hz pass through with little or no attenuation. The 5V rail is used as a convenient DC bias point, to bring the signal within IC2's supply rails, ie, roughly half-way between 0V and V_{CC} which is typically 8.7V.

IC2b operates as a simple buffer, feeding the following third-order active low-pass filter based around op amp stage IC2a which has a gain of two

Features & Specifications

- Converts infrasonic sound waves into audible waves via frequency shift modulation
- Minimal delay between detection of infrasound and audible response; essentially real-time
- Output volume proportional to infrasonic wave amplitude
- Output pitch deviation indicates infrasonic wave polarity
- Optional digital filter to compensate for typical low-frequency microphone roll-off
- Quick response time allows listener to determine nature of infrasound (pulsed, continuous, etc) as well as frequency and amplitude
- Operating input frequency range: approximately 1-20Hz
- Power supply: 9V battery, ~60mA current drain (9-15V DC plugpack can also be used)
- Five modes: AM+FM with or without microphone response compensation, AM only with or without microphone response compensation, FM only (fixed amplitude)



INFRASOUND SNOOPER

Fig.1: the complete circuit diagram. The infrasound is picked up by an electret microphone & then buffered, filtered & amplified by IC2b-IC2a before being fed to microcontroller IC1. IC1 digitises the signal & carries out the necessary signal processing before feeding it to DAC IC3. IC3 then feeds gain stage IC2d which in turn drives the output socket (CON5).

(set by the pair of 22kΩ resistors at its pin 2). The filter is a Butterworth type which is pretty much flat from DC up to 20Hz, with gain rapidly falling off at higher frequencies.

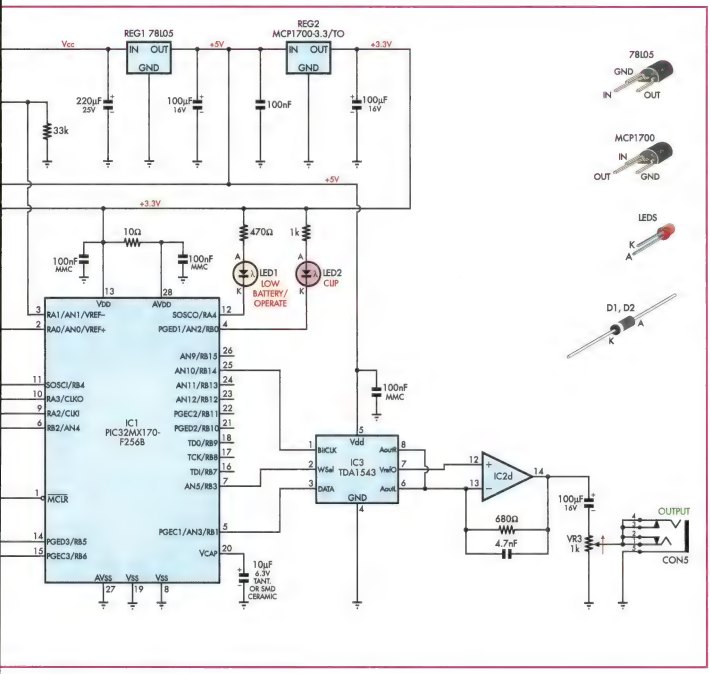
This is important since we need to apply a fair bit of gain to the infrasonic signals to scale them to an appropriate level for the microcontroller's ADC (~1V RMS). Op amp IC2c provides the requisite gain which is variable using VR2. So the gain ranges from a minimum of 6x (47kΩ ÷ (10kΩ + 470Ω) + 1) to a maximum of around 100x (47kΩ ÷ (470Ω + W) + 1, where W is VR2's wiper resistance). Thus VR2 acts as the unit's sensitivity adjustment.

The signal must then have its DC bias shifted to suit the PIC32MX microcontroller's ADC, which runs from a 3.3V regulated rail. Thus it is AC-coupled with a 1µF capacitor and biased with a pair of 2.2MΩ resistors forming a voltage divider between the 3.3V rail and ground. This sets the DC level at pin 2 of IC1 at around 1.65V. The 6.8kΩ resistor protects IC1 from high voltages from IC2 during power-up, power-down and high signal excursions.

IC1 digitises the signal and then applies some DSP-based filtering to correct for low-frequency roll-off due to the two coupling stages and the microphone's response. To create an audible signal, the infrasound signal is rectified and then used to amplitude modulate a sinewave at about 200Hz.

Some frequency modulation is normally also applied to this waveform, based on the pre-rectification signal. This allows the polarity of infrasonic excursions to be distinguished, based on the difference in resulting signal frequency.

This modulated signal appears in digital (I^2S) format at pins 5, 7 & 25 of IC1. The serial audio data is produced at pin 5 (RB1) which is mapped to one of the two internal SPI peripherals so that the data stream is uninterrupted.



This data is clocked by a signal from pin 25 (RB14/SCK1). The left/right "word" clock is produced at pin 7 (RB3), also by the SPI peripheral, using its audio framing feature.

These three signals pass to IC3, a TDA1543 16-bit oversampling DAC. We've used this chip for a number of reasons: it's available in an 8-pin DIL package which is easy to solder; it runs from a single 5V rail; it's quite cheap; it's easy to interface to and its audio performance is respectable.

Its outputs at pins 6 & 8 are current sink stages and since we only need a mono signal, they are simply connected together, filtered (to remove the digital aliasing artefacts) and converted to a voltage by remaining op amp IC2d. The 680Ω resistor sets the output voltage swing.

IC2d's pin 12 non-inverting input is connected to the 2.2V reference voltage which sets the DC level of the resulting signal. The Vref (pin 7) of IC3 has a dual purpose; the current drawn from this pin is internally amplified and added to the current sink by the left & right output pins. However, in this case, the circuit works best with no extra current sink, hence there is no load on the Vref pin.

The DC in the output of IC2d is blocked by a 100µF electrolytic capacitor and biased to ground by the track of VR3, the volume potentiometer. The headphones or earphones are connected to its wiper via CON5 with no extra buffering. This is a relatively crude system but it works well enough. The main purpose is to allow the user to reduce the output to a comfortable level when used in conjunction with sensitive earphones.

Power supply

The Infrasound Snooper is designed to run off a 9V battery but a 9-15V DC plugpack could also be used. The supply current therefore flows through one of two reverse-polarity protection

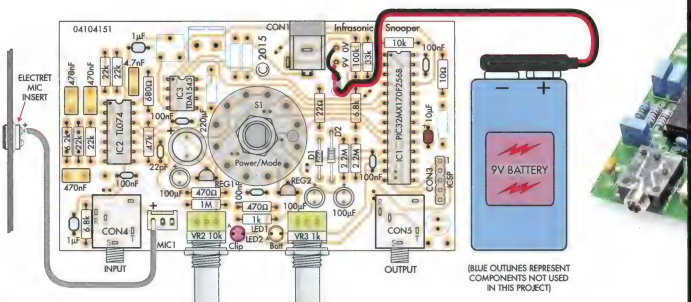


Fig.2: follow this parts layout diagram to build the PCB. Take care to ensure that all polarised parts are correctly orientated and use a socket for microcontroller IC1. Sockets are optional for IC2 & IC3.

diodes, D1 for the plugpack or D2 for the battery. D2 is a Schottky diode, to minimise voltage drop and therefore extend battery life.

Rotary switch S1 acts as both the power and mode switch. One pole connects the power supply directly to IC2 as well as to the input of REG1. This regulator provides the 5V rail for DAC IC3, the electret supply and for signal biasing in the input filter. It also feeds REG2, a 3.3V low-dropout regulator which powers microcontroller IC1.

The other pole of S1 is connected to pins 6, 9, 10 & 11 of IC1 which are configured as inputs with internal pull-up currents enabled. Thus IC1 can sense which position S1 is in by determining which of these inputs is pulled low. If none are then the switch must be in the second position, as the circuit is not powered in the first position.

IC1 monitors the battery voltage via a 4:1 divider (100kΩ/33kΩ), digitising the resulting voltage at its AN1 analog input (pin 3). If the battery voltage is low (<7V), it illuminates the low-battery LED (LED2) via its pin 12 output (RA4). The 470Ω current-limiting resistor sets the LED current to around 2-3mA.

Similarly, IC1 can light LED1 if there is an input signal overload, using its pin 4 output. The red LED is a little more efficient so operates at a lower current, with a 1kΩ current-limiting resistor resulting in around 1-1.5mA flowing.

CON3 is a programming header for IC1 (if required) with a 10kΩ pull-up resistor on its MCLR pin (pin 1) preventing unexpected reset events. IC1's analog supply at pin 28 is low-pass filtered with a 10Ω resistor and 100nF bypass capacitor, while a 10µF capacitor at pin 20 is required for its internal core regulator.

Construction

All the parts except for the electret microphone are mounted on a double-sided PCB coded 04104151 (104 x 60.5mm). This can be clipped into a standard UB3 jiffy box.

Fig.2 shows the parts layout on the PCB. Start by fitting the fixed resistors. Table 1 shows the resistor colour codes, although it's better to check the values using a DMM. Note that since the same PCB was used for the Low Frequency Distortion Analyser, there are a number of component positions which are not populated (including some resistor locations).

Diodes D1 & D2 can go in next, noting that D1 is a 1N4004 while D2 is a 1N5819. Be sure to orientate them correctly, with their striped cathode ends towards the bottom edge of the PCB.

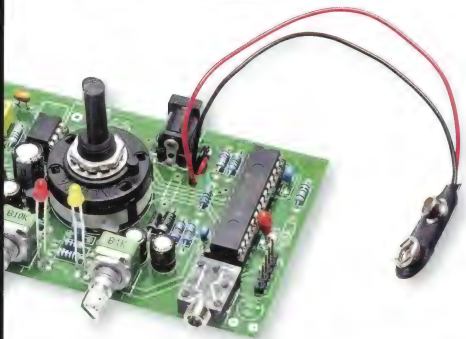
Follow with the IC socket(s). It's a good idea to use a socket for microcontroller IC1 but they are not really necessary for IC2 & IC3. Instead, IC2 & IC3 can be soldered directly to the PCB for greater long-term reliability. Either way, make sure that the pin 1 notch/dot of each IC goes towards the top of the board. This is especially critical if soldering the ICs in without sockets since you can't easily remove them once they're in!

The two jack sockets are next on the list, followed by the ceramic and MKT capacitors. REG1 & REG2 can then go in but be careful not to get them mixed up as they look similar. Their leads will need to be cranked out using needle nose pliers to suit the pad spacing on the PCB.

Now solder the DC socket in place, followed by the electrolytic capacitors. Be sure to orientate the electros correctly, with the longer (positive) leads towards the top edge of the PCB (see Fig.2). If using a tantalum type rather than an SMD ceramic for the 10µF capacitor, it too is polarised and can go in now.

Now fit the two 9mm potentiometers. They're different values so don't get them mixed up (the 1kΩ pot may be marked "102" and the 10kΩ pot "103"). The polarised 3-pin header (for the microphone) can then be fitted with its keyway tab orientated as shown.

The battery snap is next. Pass its leads through the two strain relief holes before soldering its leads to their respective pads on the top of the PCB as shown in Fig.2. You can then pull the leads back through the holes to reduce the slack. Note that they will probably be a tight fit, to provide the



This view shows the completed PCB assembly. Note how the battery snap leads are looped through strain relief holes before being soldered to the top of the PCB.

necessary strain relief.

The two 3.5mm switched jack sockets (CON4 & CON5) can now be mounted. Check that they sit flush against the PCB before soldering their pins. CON3, the ICSP header, can then go in but can be omitted if you're using a pre-programmed microcontroller.

Rotary switch S1 is mounted after first cutting its shaft so that it's 30mm long, as measured from the top surface of the main body. This can be done using a hacksaw and the end of the shaft then cleaned up with a file to remove any burrs. It must be installed with its polarity-indicating plastic post orientated as shown on Fig.2 (ie, at the three o'clock position). Again, make sure it's pushed down flat against the board before soldering its pins.

Finally, solder the two LEDs in place. The longer leads are the anodes and go into the pads indicated with "A" on Fig.2. Tack solder these in place at full lead length; you can adjust the height and solder them properly once the box has been prepared.

Microphone cable

The next job is to make up a cable to connect the microphone. That's done using a 70mm length of light-duty Fig.8 cable which is terminated at one end in a 2-way polarised header.

Begin by removing about 3mm of insulation from the leads at each end of the cable, then carefully solder and crimp the leads at one end to the header crimp pins. That done, the crimp pins can be slid into the header (the tang goes into the narrow channel) until they lock into position.

The next step is to determine which lead on the electret microphone is the positive and which is the negative. This may be marked but if not, use your DMM (set to ohms) to determine which lead is connected to the case – this is the negative (ground) lead.

Next, slip 5mm-lengths of 3mm-diameter heatshrink over the insulation at the end of the cable leads, then solder these two leads to the microphone. Make sure that the positive lead from the header goes to the electret positive (the positive side is marked on the PCB, adjacent to CON4).

Once the two leads have been soldered, slip the heatshrink sleeves over the solder connections and shrink them down to provide strain relief (see photo).

Testing

If using sockets, plug in the ICs, with their pin 1 dot or notch aligned as shown in Fig.2. If IC1 hasn't already been programmed (you can buy a pro-

Table 2: Capacitor Codes

Value	μF Value	IEC Code	EIA Code
1μF	1μF	1u0	105
470nF	0.47μF	470n	474
100nF	0.1μF	100n	104
4.7nF	.0047μF	4n7	472
22pF	NA	22p	22

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	2.2MΩ	red red green brown	red red black yellow brown
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	4	22kΩ	red red orange brown	red red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	2	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	6.2kΩ	blue red red brown	blue red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	22Ω	red red black brown	red red black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

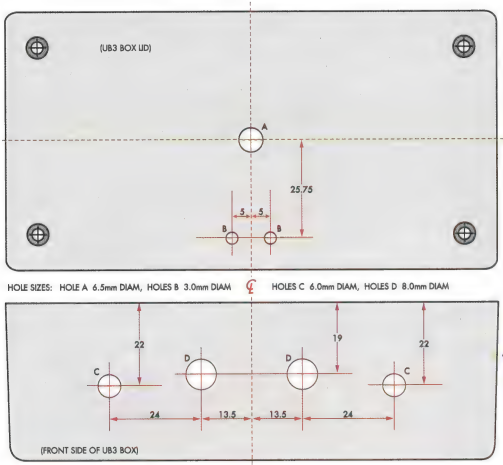


Fig.3 (left): use this full-size template to drill the holes in the lid and front side of the UB3 case.

Fig.4: this front panel artwork can be copied and used direct or a PDF version can be downloaded from the SILICON CHIP website & printed onto photo paper or onto Datapol/Dataflex label paper.

grammed micro from the SILICON CHIP Online Shop), do it now via CON3. External power can be supplied from the programmer (eg, a PICkit 3).

Once all the ICs are in place, you can test the unit as follows:

(1) Rotate S1 to the off position (fully anti-clockwise), then connect the battery.

(2) Rotate S1 one step clockwise and check that the yellow LED flashes briefly, then periodically.

(3) Turn VR2 & VR3 all the way down and connect a pair of headphones or earphones to the unit.

(4) Turn VR2 & VR3 up slowly and blow on the microphone insert. After turning the pots up sufficiently, you should hear the modulated signal from the low frequency components of this sound. With the gain up high, if you blow hard enough, the overload (red) LED may light.

(5) Switch S1 to the other positions and check that the sound produced by the unit changes.

(6) Switch the unit off and remove the battery.

If it doesn't work as expected, carefully inspect the solder joints under magnification. Also check that the components are all in their correct positions and that the polarised parts (diodes, ICs, electrolytic capacitors etc) are orientated correctly.

Case preparation

If fitting the PCB into a UB3 jiffy box, you will need to drill four holes in the side of the case for the microphone input and headphone output sockets, plus the gain and volume adjustment knobs. The bottom section of Fig.3 shows the relevant drilling template – this can be copied (or downloaded from the SILICON CHIP website and printed out) and temporarily stuck to the side of the case (eg, using double-sided tape).

Note that the top edge of the template must be aligned with the top edge of the box and centred horizontally.

The holes must be accurately placed.

Above: the PCB is a snapfit inside the case, while the battery sits on a piece of non-conductive foam (see text).

Start by drilling pilot holes (eg, 3mm) in each location and then enlarge them using larger drill bits, a stepped drill bit or a tapered reamer. Clean up any burrs, then remove the nuts from the two jack connectors, screw the nuts and washers all the way onto the potentiometers and check that the connectors and pots fit through the holes.

If you want to be able to run the unit from a plugpack, you will also need to drill a 5.5mm hole in the other side, to allow access to the connector. The same template can be used; simply drill the hole for the power jack centred on the same location as that used for the volume control pot on the opposite side. If in doubt, check the location of the power socket on the board before drilling.

Fitting the microphone

A hole also has to drilled in the lefthand end of the case for the electret microphone. The hole should be positioned about 16mm down from the top of the case and centred horizontally. Start by drilling a small pilot hole, then carefully ream the hole out until the microphone is a tight fit.

Once the mic fits, adjust it so that its face is flush with the outside of the case. It can then be secured inside the case using a small amount of neutral-cure silicone adhesive and the assembly placed aside to cure while the case lid is drilled.

Front panel drilling

Three holes are required in the case lid, for the two LEDs and switch S1. The drilling template is at the top of Fig.3 and it's just a matter of drilling the holes to size and checking that the LEDs and switch shaft fit.

The next step is to make and attach the panel label (Fig.4). This can be copied or downloaded and printed onto photo paper and affixed to the panel using silicone adhesive. Alternatively it can be printed onto Datapol/Dataflex label paper and stuck onto the lid. The three holes are then cut out using a sharp hobby knife.

Final assembly

Assuming that the silicone around the microphone has cured, the PCB can now be installed in the case. It's just a matter of angling the front of the board down so that the sockets and pot shafts go into their respective holes, then pushing down on the back of the board until it snaps into the integral side-rails. If it won't go in, you may need to enlarge the holes slightly.

Now trial fit the lid. If the LED heights are wrong, you will need to remove the PCB and adjust them accordingly. Once they fit properly, re-solder their leads and re-install the board in the case. The potentiometer nuts can then be wound forwards until they're against the inside face of the case.

Next, rotate S1 to off (fully anti-clockwise), then connect the battery and place it on top of the PCB with a piece of non-conductive foam sandwiched in between. This will prevent shorts and also stop the battery from rattling around inside the case.

Finally, screw the lid in place, then

Parts List

1 double-sided PCB, coded 04104151, 104 x 60.5mm
1 UB3 jiffy box (optional)
1 10kΩ 9mm single-gang potentiometer (VR2)
1 1kΩ 9mm single-gang potentiometer (VR3)
1 28-pin narrow DIL IC socket
1 14-pin DIL IC socket (optional)
1 8-pin DIL IC socket (optional)
1 piece non-conductive foam, approximately 65 x 40 x 8mm
1 PCB-mount DC socket (CON1)
2 3.5mm switched jack sockets (CON4,CON5)
1 2-pole 6-position rotary switch (S1)
1 medium-sized knob, to suit S1
2 small knobs, to suit VR2 & VR3
1 9V battery snap (BAT1)
1 9V alkaline battery (BAT1)
1 pair headphones or earphones
1 5-pin header, 2.54mm pitch (CON3) (optional – see text)
1 PCB-mount electret microphone insert (Jaycar AM4011)
1 3-pin polarised header, 2.54mm pitch (CON6)
1 3-way polarised header plug
1 70mm-length light duty figure-8 cable
1 10mm length 3mm-diameter heatshrink

Semiconductors

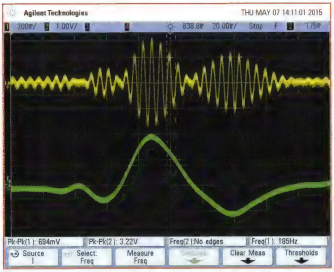
1 PIC32MX170F256B-I/SP 32-bit microcontroller programmed with 0420415A.HEX (IC1)
1 TL074 quad JFET-input op amp (IC2)
1 TDA1543 oversampling DAC (IC3)
1 78L05 5V regulator (REG1)
1 MCP1700-3.3/TO 250mA 3.3V LDO regulator (REG2)
1 red 3mm LED (LED1)
1 yellow/orange 3mm LED (LED2)
1 1N4004 1A diode (D1)
1 1N5819 1A Schottky diode (D2)

Capacitors

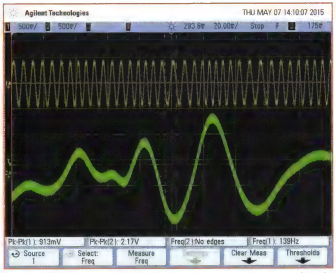
1 220µF 25V electrolytic
3 100µF 16V electrolytic
1 10µF 6V tantalum or SMD ceramic (1210/1206/0805)
2 1µF 50V multi-layer ceramic
3 470nF 63V/100V MKT
5 100nF 50V multi-layer ceramic
1 4.7nF 63V/100V MKT
1 22pF disc ceramic

Resistors (0.25W, 1%)

2 2.2MΩ
1 1MΩ
1 100kΩ
1 47kΩ
1 33kΩ
4 22kΩ
1 10kΩ
2 6.8kΩ
1 6.2kΩ
1 1kΩ
1 680Ω
2 470Ω
1 22Ω
1 10Ω



Scope3: amplitude modulation-only mode. The output frequency is fixed at around 185Hz and only its amplitude varies, increasing for either polarity of infrasound pressure wave excursion. Each waveform shown here is at maximum sensitivity and this is how the unit should be used unless it is overloading due to intense infrasound.



Scope4: frequency modulation mode. The signal amplitude is constant and high (generally the output volume should be turned down in this mode) and only the frequency changes in response to infrasonic waves picked up by the microphone. As before, the frequency increases for one polarity of wave and decreases for the other.

attach the knobs for S1, VR2 & VR3 (the jack socket nuts aren't required).

Using it

Typically, you would use the device with the gain somewhere near maximum and the volume adjusted to a level which is not excessive for the headphones or earphones being used. Due to the way the volume control works, this is likely to be somewhere near maximum too, although lower settings may be necessary for "in-ear" ear-phones.

Sealed headphones or in-ear phones have the advantage that you can more easily determine the level of infrasound emitted from sources which also produce audible frequencies. That's because they will do a better job of blocking those audible frequencies out and allow you to more clearly hear the output of the device.

An example of this would be a door slamming shut. This can generate quite a significant infrasonic pulse but it may be difficult to hear the unit's response against the audible noise of the door slamming. Other sources which can be used to test the unit include large air-conditioning units, passing trucks and large idling engines.

When using one of the frequency modulation (FM) modes, it is possible to determine the polarity of an infrasonic pulse. One polarity will produce a sound which increases in frequency while the other will produce a sound that decreases in frequency. Regular pulses from the same source will normally have a consistent polarity. Typically, a compression wave will precede an expansion wave.

Finally, note that a wind shield may be necessary for the microphone if the unit is used outdoors. As with the March 2013 Infrasound Detector, the windshield from a dynamic microphone could be used.

Alternatively, a separate external electret microphone (plugged into CON4) could be used instead of the inbuilt electret. Just make sure is has the required high sensitivity, a good low-frequency response and is able to operate from the ~0.5mA bias current supplied by the unit. SC

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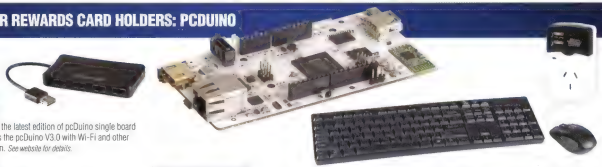

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AC1000V EN60900

TD-2330

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- 185(H) x 260(W) x 400(D)mm

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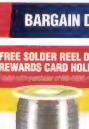

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Professional quality machine for quick and convenient cleaning of industrial parts, electronic equipment and more. Features large 2.5L stainless steel bowl and controllable heating element.

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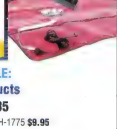

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- Auto-ranging, data hold, relative measurement

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Security	Cat IV 600V			
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Amp DC/AC	10A			
Resistance	40M			
Frequency	10MHz			
Capacitance	100µF	100µF	40mF	40mF
RRP	$79.95	$109	$159	$229

SPECIAL $64.95 QM-1549 — **SAVE $15**

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Mini IP67 Infrared Thermometer
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Ultra compact, non-contact thermometer with LCD readout in Celsius or Fahrenheit. 1:1 distance to spot ratio.

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- -50 to +1300°C (±0.5%)
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SMART DATA TOOLS
FOR ON-SITE TESTING & DIAGNOSIS

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IDEAL FOR CHECKING BUILDINGS AFTER ALL THE RAIN

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An intelligent meter with 8mm electrode suitable for measuring water content in building materials and wooden fibre articles.
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- 96(H) x 40(W) x 20(D)mm
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ALSO AVAILABLE:

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Network Cable Tracer
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Easily trace cables even when cables are in a bundle or hidden in punchdown blocks or wall plates. Also checks telephone line polarity and status ie. ring/busy/idle.
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USB Mini Inspection Cameras
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NOW $99 SAVE $30

Professional Light Meter
QM-1584 **WAS $129**

Extremely accurate with a rapid response and can store min and max values for easy comparisons. Measurement can be switched between Lux and FC (foot candles).
- Max 400k lux
- Separate photo detector

NOW $109 SAVE $30

Professional Laser Distance Meter
QM-1622 **WAS $139**

This highly accurate unit allows you to easily measure the distance between two points beyond the common tape measure. It also allows you to automatically calculate area, volume or height.
- Measurement 0.05 to 35m (±1.5mm)
- Stores up to 20 measurements

NOW $329 SAVE $70

Professional Sound Level Meter **WAS $399**
QM-1592

Scales for A and C weighting are included so it's ideal for vehicle noise testing, traffic noise or any evidence-based noise testing.
- 30 to 130dB (±1.4dB)
- IEC 61672-1 Class 2 compliant

$44.95 SAVE $15

3-In-1 Stud Detector
WITH LASER LEVEL
QP-2288 **WAS $59.95**

Indicates proximity when you are near a stud via its large LCD and shows a target graphic when you're spot on. Built-in voltage detection.
- Detects wood, metal and live wire
- Thumb dial adjustable feet for levelling the laser

REWARDS CARD OFFER: UP TO 35% OFF THESE AUTO TESTERS*

**Valid for purchase of QP-2258, QP-2212, QM-1494, or QM-1448.*

REWARDS CARD SPECIAL $7.95 SAVE $5

3-In-1 Auto Tester
QP-2258 **$12.95**

Quickly check the condition of your 12V battery, charger or alternator. Compact & lightweight. 12VDC.

RUGGED METAL BODY!

REWARDS CARD SPECIAL $9.95 SAVE $4

Cordless Voltage Tester
QP-2212 **$15.95**

Quick and easy way to locate electrical faults without a bulky meter or ground wire. Works on 3-28V circuits. It lights up and buzz when positive voltage is detected. Probe is supplied with a V-Groove tip to make piercing wire insulation safe.

REWARDS CARD SPECIAL $44.95 SAVE $15

Multi-Function Circuit Tester
QM-1494 **$59.95**

Designed for 12/24V vehicles, it tests polarity, voltage, short/open status, lights and more. Quickly test circuits without using jumper wires. All the features of a brand name unit at a fraction of the price.

REWARDS CARD SPECIAL $59.95 SAVE $20

Digital Tachometer
QM-1448 **$79.95**

Measures up to 99,999RPM and can also count revolutions. Large LCD screen, laser pointer and min/max recall. 5 digits display.
Four AA batteries included.

See terms & conditions on page 8.

UP TO 70% OFF CLEARANCE STOCK

TEST & TOOLS

See website for technical specifications

PCB Holder
WITH 90MM MAGNIFYING GLASS
TH-1983
ORRP $12.95

NOW $9.95
SAVE $3

PCB not included

Repair Kit for iPhone®
19 PIECE
TD-2113
ORRP $29.95

NOW $17.95
SAVE $12

Network Cable Tester - UTP/STP/ Coax/Mod
XC-5076
ORRP $39.95

NOW $19.95
SAVE $20

Electronic Tool Kit
30 PIECES
TD-2107
ORRP $29.95

NOW $21.95
SAVE $8

Forehead & Ear Thermometer
QM-7271 **ORRP $29.95**

NOW $19.95
SAVE $10

Ear Thermometer
QM-7272
ORRP $34.95

NOW $22.95
SAVE $12

Body Thermometer
WITH SMARTPHONE APP
QM-7201
ORRP $89.95

NOW $69.95
SAVE $20

USB Digital Microscope 2MP
WITH 200X ZOOM
QC-3197
ORRP $79.95

NOW $54.95
SAVE $25

SAVE UP TO 70%

CAT. NO.	PRODUCT		ORRP	NOW	SAVE
SF-5122	Blade Fuse Mini Wire Tap 15A	HOT!	$6.95	$1.95	$5.00
RQ-5269	Crystal 10MHz HC49U	HOT!	$4.50	$1.50	$3.00
RQ-5258	Crystal 38kHz DT38 Miniature	HOT!	$4.50	$1.50	$3.00
RQ-5265	Crystal 6MHz HC49U		$4.50	$1.50	$3.00
PS-0532	DC Socket 0.7mm PCB Mnt with Slide Switch		$5.95	$2.95	$3.00
PP-1154	IDC Locking Right-Angle Header 16 Pin	HOT!	$1.75	$0.75	$1.00
PP-1148	IDC Locking Vertical Header 50 Pin		$3.75	$1.95	$1.80
PP-1128	IDC Right-Angle Header 34 Pin	HOT!	$2.25	$0.95	$1.30
PA-3692	Plug 1.75mm to Suit Plugpack - Green Dot		$2.95	$1.65	$1.30
PA-3690	Plug 1.7mm to Suit Plugpack - Blue Dot		$2.95	$1.65	$1.30
HC-4066	Power Terminal Gold Plated 2GA		$8.95	$4.95	$4.00
HC-4052	Power Terminal Gold Plated 4GA		$8.95	$4.95	$4.00
PP-0209	RCA Plug Crimpless - Green	HOT!	$3.50	$1.50	$2.00
PS-0280	RCA Socket Double - PCB Mount		$1.95	$0.95	$1.00
HH-8607	TO-220 Dual Heatsink Clamp Pk 100		$19.95	$11.95	$8.00
HP-1155	TO-220 Rubber ORRPer Pk100		$17.95	$7.95	$10.00
ZV-1637	Voltage Regulator LM2678T-12	HOT!	$16.95	$8.95	$8.00
ZZ-8800	Water Cord with PIC16F84A + 24LC16B		$11.95	$5.95	$6.00
PI-6483	ZIF Socket 28 Pin	HOT!	$14.50	$6.50	$8.00

HARDCORE COMPONENTS

See website for technical specifications

PLCC Socket Surface Mount 84 Pin
PI-6630 **ORRP $5.95**

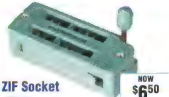
NOW 95c
SAVE $5

D-Sub Socket 25-Pin Waterproof
PS-1220 **ORRP $19.95**

NOW $12.95
SAVE $7

Power Terminal Gold Plated 0GA
HC-4068 **ORRP $8.95**

NOW $3.95
SAVE $5



ZIF Socket 40 Pin
PI-6484 **ORRP $15.50**

NOW $6.50
SAVE $9

AUTO & OUTDOORS

See website for technical specifications

NOW $9.95
SAVE $10

Car Charger/Audio Kit
FOR IPHONE®/IPOD® MB-3653 **ORRP $19.95**

NOW $24.95
SAVE $10

iPhone not included.

Car Holder & FM Transmitter
FOR IPHONE®5 AR-3125 **ORRP $34.95**

NOW $64.95
SAVE $15

Car Mini Dash Cam 1080p QV-3846 **ORRP $79.95**

NOW $169
SAVE $30

Reversing Camera
WITH 5 INCH LCD MONITOR
QM-3741 **ORRP $199**

Car OBD2 Computer Memory Saver
PP-2140 **ORRP $9.95**

NOW $4.95
SAVE $5

Map Measure Digital
WITH LED LIGHT
XC-0374
ORRP $9.95

NOW $5.95
SAVE $4

12-24VDC Siren Waterproof
LA-8903
ORRP $34.95

NOW $24.95
SAVE $10

Rechargeable Camping Shower
YS-2802
ORRP $39.95

NOW $27.95
SAVE $12

UP TO 80% OFF CLEARANCE STOCK

AUDIO & VIDEO

See website for technical specifications

SAVE UP TO 80%

CAT. NO.	PRODUCT		ORRP	NOW	SAVE
WQ-7299	3.5mm/Toslink Fibre Optic Swappable Lead	HOT!	$14.95	$6.95	$8.00
AA-0373	Amplifier Module Mono 0.5W	HOT!	$11.95	$5.95	$6.00
AA-2097	Handsfree Aux Mic Lead For Smartphones		$9.95	$5.95	$4
AR-1895	Amplifier Stereo Wireless 2.4GHz 15WRMS		$99.00	$49.00	$50.00
LT-3205	Antenna Mount Adjustable Bracket		$24.95	$16.95	$8.00
WQ-7298	Audio Lead Toslink-3.5mm Fibre Optic - 1m	HOT!	$9.95	$4.95	$5.00
SL-3441	Disco LED RGB Light - Flashing		$79.95	$59.95	$20.00
AS-2084	Earphones for Kids with Volume Limiter	HOT!	$9.95	$3.95	$6.00
AA-2069	Earphones Stereo/Bluetooth®/Rechargeable		$74.95	$54.95	$20.00
AA-2079	Earphones with TV Hearing Aid		$129.00	$79.00	$50.00
AM-4087	Microphone/Desktop 3.5mm Plug		$12.95	$7.95	$5.00
AX-3598	Speaker Protection Grille 15" with Clips	HOT!	$12.00	$2.00	$10.00
PT-0475	Wallplate Multimedia VGA/HDMI/RCA/3.5mm		$29.95	$19.95	$10.00
YN-8059	Wallplate VGA Socket with 4 Parts		$9.95	$4.95	$5.00

NOW $79.95
SAVE $20

Cassette Player
WITH USB/SD ENCODER
GE-4139 **ORRP $99.95**

NOW $99
SAVE $20

HDMI Switcher 4 Input
WITH AUDIO RETURN
AC-1709 **ORRP $119**

NOW $44.95
SAVE $15

Video Converter DVI to VGA
WQ-7445 **ORRP $59.95**

NOW $69.95
SAVE $30

Speaker Stand
EXTRA HEAVY DUTY
CW-2860 **ORRP $99.95**

IT & COMMUNICATIONS

See website for technical specifications

SAVE UP TO 60%

CAT. NO.	PRODUCT		ORRP	NOW	SAVE
WC-7729	Adaptor Plug - Micro-B USB to Lightning	HOT!	$14.95	$6.95	$8.00
MB-3695	Battery Back-up Case to suit iPhone 5®		$39.95	$29.95	$10.00
HS-9016	Bicycle Bracket Mount for iPhone 3/4®	HOT!	$19.95	$7.95	$12.00
WC-7717	Docking Station for Apple® to HDMI Device	HOT!	$49.95	$24.95	$25.00
AR-1889	Docking Station/Speaker for iPhone®/iPod®	HOT!	$49.95	$24.95	$25.00
AR-3320	FME to Telstra 4G USB Modem Cable	HOT!	$16.95	$6.95	$10.00
XC-5202	Keyboard Foldable with Bluetooth®		$39.95	$24.95	$15.00
XC-4949	KVM & Data Transfer USB Cable		$49.95	$34.95	$15.00
XC-5412	Laser Pointer Plug-in for iPod®/iPhone®		$19.95	$11.95	$8.00
WC-7510	RS232 Extension Computer Lead 3m		$19.95	$11.95	$8.00
XC-5220	Speaker Wireless - Near Field Audio		$39.95	$24.95	$15.00
XC-4691	USB 3.0 Cloud Dock		$99.00	$59.00	$40.00
XC-4143	USB 3.0 Dual Port PCI-E Interface Card		$34.95	$29.95	$5.00
WC-7736	USB Retractable Lead A-Plug to MicroB Skt	HOT!	$11.95	$6.95	$5.00
YN-8364	Wi-Fi Extender Dual Band		$89.95	$64.95	$25.00

NOW $27.95
SAVE $12

Stereo Car Handsfree Kit
WITH BLUETOOTH® TECHNOLOGY
AR-3130 **ORRP $39.95**

NOW $34.95
SAVE $15

Panel Mount Bluetooth Receiver WITH MIC
AR-3129 **ORRP $49.95**

NOW $39.95
SAVE $20

Wireless Presenter
WITH MOUSE AND LASER
XC-5413 **ORRP $59.95**

NOW $399
SAVE $50

UPS Online Rack Mountable 1000VA/700W MP-5212 **ORRP $449**

SECURITY & SURVEILLANCE

See website for technical specifications

SAVE UP TO 70%

CAT. NO.	PRODUCT		ORRP	NOW	SAVE
QC-8627	Bullet Camera Weatherproof with IR 600TVL		$99.95	$69.95	$30.00
MP-3351	CCTV Power Distributor Box		$39.95	$24.95	$15.00
QC-8644	Dome Camera CCD 3-Axis with IR 800TVL		$149.00	$119.00	$30.00
LA-5224	Doorbell Wireless with MP3 Music		$44.95	$29.95	$15.00
SL-3232	Emergency Spotlight Rechargeable with PIR		$49.95	$27.95	$22.00
LA-5156	Intelligent GSM Wireless Alarm System		$299.00	$209.00	$90.00
LA-5355	Keypad Security 12VDC		$39.95	$29.95	$10.00
LA-5214	Keypad Shed Alarm	HOT!	$19.95	$8.95	$11.00
LA-5262	Siren with 10 Sounds and Mic 12V		$44.95	$39.95	$5.00
LA-5305	Solar Powered Magnetic Entry Alarm	HOT!	$19.95	$4.95	$15.00
LA-5174	Solar Wireless PIR Annouricor	HOT!	$59.95	$27.95	$32.00
LA-5304	Strobe Light Mini - Orange	HOT!	$24.95	$9.95	$15.00
LA-5303	Strobe Light Mini - Red	HOT!	$24.95	$9.95	$15.00
LA-5163	Water Leakage Alarm 120dB Siren		$9.95	$6.95	$3.00

NOW $99
SAVE $50

Bullet Camera CCD
WITH IR 650TVL QC-8634 **ORRP $149**

NOW $99
SAVE $50

Dome Camera CCD
WITH IR 650TVL QC-8636 **ORRP $149**

NOW $79.95
SAVE $20

Wi-Fi IP Camera Ai-Ball VGA QC-3368 **ORRP $99.95**

NOW $549
SAVE $150

DVR 16-Channel Network
WITH 1TB HDD QV-3039 **ORRP $699**

UP TO 60% OFF CLEARANCE STOCK

Listed below are a number of discontinued (but still good) items that we can no longer afford to hold stock. Please ring your local store to check stock. At these prices we won't be able to transfer from store to store. **STOCK IS LIMITED. ACT NOW TO AVOID DISAPPOINTMENT. SORRY NO RAINCHECKS.**

POWER & LIGHTING

See website for technical specifications

CAT. NO.	PRODUCT		ORRP	NOW	SAVE
HH-8549	Aluminium Extrusion 2-Pce for LED Strip 1m	HOT!	$29.95	$14.95	$15.00
HH-8547	Aluminium Extrusion for LED Strip 1m	HOT!	$22.95	$10.95	$12.00
SB-2540	Battery Lithium 3.6V for Motherboard		$15.95	$5.95	$10.00
MB-3605	Battery Backup with Lightning™ Connector		$34.95	$19.95	$15.00
MB-3646	Battery Bank with iPod® Charger 5000mAh		$59.95	$39.95	$20.00
HM-3086	Battery Clamps Stainless Steel 400A		$9.95	$4.95	$5.00
ST-3206	LED Backup/Reading Light		$19.95	$11.95	$8.00
SL-2220	LED Candle Globe E14 2800K 3.2W 230Lm		$19.95	$11.95	$8.00
SL-2222	LED Candle Globe E14 4000K 3.2W 230Lm		$19.95	$11.95	$8.00
ST-3291	LED Cap Torch 160Lm		$12.95	$7.95	$5.00
SL-3140	LED Desk Lamp with USB Charger		$39.95	$29.95	$10.00
SL-3458	LED Downlight "Hockey Puck" Style 45Lm		$17.95	$12.95	$5.00
ZD-0373	LED Downlight Kits 3000K 15W 900Lm	HOT!	$99.00	$39.00	$60.00
AA-0595	LED Driver Constant Current - Dimmable		$12.95	$9.95	$3.00
ST-3085	LED Emergency Light with Magnetic Base		$14.95	$9.95	$5.00
SL-2210	LED Globe Dimmable/Bayonet 2800K 5W 400Lm		$14.95	$9.95	$5.00
SL-2216	LED Globe Dimmable/Bayonet 4000K 10W 900Lm		$29.95	$17.95	$12.00
SL-2231	LED Globe Dimmable/Screw 2800K 5W 500Lm		$22.95	$12.95	$10.00
SL-2207	LED Globe Dimmable/Screw 6000K 10W 900Lm		$29.95	$17.95	$12.00
SL-3472	LED Spotlight Gymbal Flush Mount 3W 165Lm		$34.95	$24.95	$10.00
ZD-0606	LED Spotlight MR16 2800K 4.5W 220Lm	HOT!	$19.95	$9.95	$10.00
ZD-0605	LED Spotlight MR16 6000K 4.5W 250Lm	HOT!	$19.95	$9.95	$10.00
SL-3465	LED Strip Lamp For Vehicles C. White 140Lm		$24.95	$19.95	$5.00
ZD-0463	LED Strip Warm White 5000K/3xBW/3mm 12V 150Lm		$14.95	$8.95	$6.00
SL-3139	LED Table Lamp 3500-6500K 270Lm		$89.95	$74.95	$15.00
ST-3341	LED Torch Multi-Functional Dynamo		$19.95	$11.95	$8.00
ST-3357	LED Torch with Radio & Dynamo Charger		$29.95	$21.95	$8.00
ST-3466	LED Torch Yellow 300 Lumens		$19.95	$11.95	$8.00
ST-2907	LED USB Flexible Light 6000K 300Lux		$14.95	$9.95	$5.00
SL-3473	LED Wall/Desk Mount Gooseneck Lamp 75Lm		$19.95	$14.95	$5.00
ST-3264	LED Worklight Low Cost 12V		$29.95	$21.95	$8.00
PP-4039	Mains Double Adaptor with Night Light	HOT!	$9.95	$4.95	$5.00
MS-6156	Mains Sockets IR Controlled Wireless	HOT!	$26.95	$9.95	$17.00
MP-3452	Mains Travel USB Adaptor		$12.95	$6.95	$6.00
ST-3460	Torch Magnetic with Gooseneck 150Lm	HOT!	$44.95	$21.95	$23.00

NOW $6.95 SAVE $8

Snap-On Battery Terminals
RED / BLACK 500A HM-3087 **ORRP $14.95**

NOW $219 SAVE $30

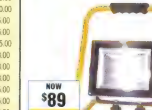
Solar Panel Monocrystalline 12V 90W ZM-9086 **ORRP $249**

NOW $24.95 SAVE $15

LED Spot / Running Lamps 12V 120Lm SL-3445 **ORRP $39.95**

NOW $29.95 SAVE $20

LED Worklight 240V IP65 600Lm ST-3263 **ORRP $49.95**



NOW $89 SAVE $30

LED Worklight Rechargeable 30W 1500Lm SL-2889 **ORRP $119**

NOW $139 SAVE $30

HID Spot / Search Light 3200Lm WITH PAN / TILT ST-3377 **ORRP $169**

DON'T MISS OUT ON OUR YEARLY CLEARANCE! VISIT OUR WEBSITE WWW.JAYCAR.COM.AU

TERMS AND CONDITIONS: REWARDS CARD HOLDERS FREE GIFT, ¼ SAVING DEALS, DOUBLE POINTS & REWARDS OFFERS require active Jaycar Rewards Card membership at time of purchase. Refer to website for Rewards Card T&Cs. **DOUBLE POINTS ACCRUED** during the promotion period will be allocated to the Rewards Card after the end of promotion. **LISTED ON PAGES 6 TO 9** are a number of discontinued (but still good) items that we can no longer afford to hold stock. Please ring your local store to check stock. At these prices we won't be able to transfer from store to store. **STOCK IS LIMITED. ACT NOW TO AVOID DISAPPOINTMENT. SORRY NO RAINCHECKS. SAVINGS OFF ORIGINAL RRP (ORRP).**

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Bankstown	Ph (02) 9709 2822
Blacktown	Ph (02) 9678 9669
Bondi Junction	Ph (02) 9369 3899
Brookvale	Ph (02) 9905 4130
Campbelltown	Ph (02) 4625 0775
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Croydon	Ph (02) 9799 0402
Dubbo	Ph (02) 6881 6778
Erina	Ph (02) 4365 3433
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Gore Hill	Ph (02) 9439 4799
Hornsby	Ph (02) 9476 6221
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Newcastle	Ph (02) 4968 4722
Penrith	Ph (02) 4721 8337
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Rydalmere	Ph (02) 8832 3120
Shellharbour NEW	Ph (02) 4256 5106
Smithfield	Ph (02) 9604 7411
Sydney City	Ph (02) 9267 1614
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Tuggerah	Ph (02) 4353 5016
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Wagga Wagga	Ph (02) 6931 9333
Warners Bay	Ph (02) 4954 9100
Warwick Farm NEW	Ph (02) 8824 3100
Wollongong	Ph (02) 4226 7089

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Capalaba	Ph (07) 3245 2014
Ipswich WE HAVE MOVED	Ph (07) 3282 5800
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Nth Rockhampton	Ph (07) 4926 4155
Townsville	Ph (07) 4772 5022
Strathpine	Ph (07) 3889 6910
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Woolloongabba	Ph (07) 3393 0777

Victoria

Cheltenham	Ph (03) 9585 5011
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Frankston	Ph (03) 9781 4180
Geelong	Ph (03) 5221 5800
Hallam	Ph (03) 8796 4577
Keilor East	Ph (03) 9359 6188
Melbourne City	Ph (03) 9663 2030
Mornington	Ph (03) 5976 1311
Ringwood	Ph (03) 9870 9053
Roxburgh Park	Ph (03) 9309 2042
Shepparton	Ph (03) 5822 4057
Springvale	Ph (03) 9547 1022
Sunshine	Ph (03) 9310 8066
Thomastown	Ph (03) 9465 3333
Werribee	Ph (03) 9741 8951

South Australia

Adelaide	Ph (08) 8231 7355
Clovelly Park	Ph (08) 8276 6901
Elizabeth	Ph (08) 8255 0999
Gepps Cross	Ph (08) 8262 3000
Modbury	Ph (08) 8263 7511
Reynella	Ph (08) 8387 3847

Western Australia

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Joondalup	Ph (08) 9301 0918
Maddington	Ph (08) 9493 4300
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Midland	Ph (08) 9250 8200
Northbridge	Ph (08) 9328 8252
Osborne Park	Ph (08) 9444 9250
Rockingham	Ph (08) 9592 8000

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Launceston	Ph (03) 6334 2777

Northern Territory

Darwin	Ph (08) 8948 4043

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Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

Arrival dates of new products in this flyer are confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP. Prices and special offers are valid from 24 May - 23 June, 2015.

SERVICEMAN'S LOG

Diversifying – it's not that easy

Dave Thompson*

Diversifying into smartphone and tablet repairs seemed like a good idea some time ago but experience has proven otherwise. And no more was this brought home to me than a scrape I got myself into with a couple of smartphones I recently wasted a lot of time on.

Items Covered This Month

- No-name smartphone repair
- Industrial machine servicing
- Modifying & repairing an off-grid battery charger

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

In this business, the name of the game is diversification. This often means changing direction and focus from an existing core business model to something new (yet hopefully complementary) in order to increase custom and income potential.

Indeed, I've talked about this before because on many levels, the computer repair industry is a dying one. The golden days enjoyed by the local computer guy have long gone due to a now much more tech-savvy public and due to turn-key software and related systems that require no specialist knowledge to set up, configure or maintain.

Ten years ago, just about every household boasted a desktop computer that was typically shared by the whole family. Sometimes there would be a couple of machines; one for the kids and one for mum and dad. These days, however, many households no longer bother with a desktop computer because the kids likely have their own smartphones and/or tablets for doing school work (and communicating with each other via social media), while mum and dad also have smart-phones and perhaps a work-supplied laptop or tablet on which to do their Internet banking, "Skypeing" and emailing.

Now I know I'm being terribly stereotypical but such generalisations hammer home my point. While in some instances a laptop, phone or tablet can never replace a desktop for some tasks (eg, high-end architectural or graphics designers), the fact remains that the number of families owning a communal desktop computer has significantly declined over the past few years.

These days, when the "family" desktop starts playing up or reaches its end-of-life, it's typically not repaired or replaced because there is no longer a need for it. And this scenario is increasingly being repeated. Understandably, people can't rationalise spending even a few hundred dollars on something they are not going to use anywhere near as much as they used to, especially when they have other gadgets that can do a similar job.

Another nail

Unfortunately, the demise of the desktop is just another nail in the coffin for the computer serviceman because a large portion of our bread and butter work goes with it. And while there can be valid arguments for repairing a laptop, in most cases they are so cheap to buy and the parts so ridiculously expensive (or not even obtainable) that repairing them has become either uneconomical or simply not feasible.

The same philosophy applies even more so to smartphones and tablets, which leaves retail sales or, at a stretch, consulting work as the only potential income streams for micro-businesses like mine. In the case of sales, however, we simply cannot compete with

Serviceman's Log – *continued*

the large retailers and as for consulting work, anyone can find out pretty much anything they need to know on Google these days – all at no cost. So shelling out even minimum wage money to get a "specialist" in isn't warranted.

When I discuss this with other people, the first thing many suggest is getting into smartphone and tablet sales and repairs. That's not a silly idea until you look at the nuts and bolts and in fact, I seriously considered doing that a few years ago when I first saw the writing on the wall for computer repairs. I even went so far as to set up tentative import chains from Asia to supply phones, tablets and even some computer hardware.

On paper and in theory, this initially looked very promising and I was extremely excited about the prospects. I could buy low and sell high enough to remain competitive and still make money but it didn't take long for the cracks to start showing.

For a start, much of the hardware wasn't up to the quality that we've come to expect. Most no-name phones look the part in the glossy promotional material and some even work quite well for a while. However, they really are built to a price and as such do not stand up to everyday use as well as their more-expensive brand-name cousins. Out of a dozen of the best quality phones I could find to import and sell, every single one came back within six months with problems that would cost more to repair than it would to simply replace the phone.

But that wasn't the end of my problems, as I found out when I tried to return them under warranty to the various suppliers. That's when the system really fell apart as not one vendor was interested in helping to sort it out. In the end, I wore the costs myself in an effort to maintain credibility with my customers. Apart from the damage to my business, what really depressed me was that my hopes had been dashed. Importing and selling products in this way was not the answer I was looking for.

The fact remains that many of today's "tech" devices are purposely engineered to be consumable – that is, to simply be replaced if or when they fail. In my experience, most people who bring in a phone or tablet with a broken screen or some other fault don't want to spend more than a few dollars to get it repaired. Indeed, most are taken aback when they discover the cost to replace an iPhone, iPad or Samsung Galaxy screen, preferring instead to use this as an excuse to go and buy a new (and usually fancier) phone. And I don't blame them one bit.

Recent experience

A recent experience of my own illustrates why it just isn't worth trying to eke out a living by importing no-name hardware from Asia or by offering to fix high-end phones and tablets, no matter how lucrative it may appear to be on paper.

My wife and I both needed new phones, with our old models years out of date and "er-in-door's" one finally giving up the ghost. As a result, she looked through some of the websites of vendors we've dealt with before online and found a brand-name phone that was reasonably priced and which boasted the features we both wanted. It certainly looked good to me and because it was branded and priced a bit higher than some of the no-name ones we'd seen in the past, we decided to take a punt and order two of them

When they arrived, it certainly looked like the gamble had paid off because the phones were beautiful, fast and had everything we could ever want in a phone. Setting them up was a breeze and transferring our data from the old phones almost too easy, so it wasn't long before we both had our respective phones on-line and in use.

But there was one small niggle: Nina's phone sometimes wouldn't hang up after making a call. The screen initially wouldn't respond to any touch commands but after about 30 seconds it would suddenly work and we could then hit the "hang up" button. By itself, it wasn't a major problem but it was annoying. What's more, it soon became apparent that the fault not only occurred when making a call because at other times, the screen would be non-responsive for about 30 seconds before suddenly becoming usable again.

At that point, I offered to swap phones because my handset didn't exhibit any of those problems. Nina uses dual SIM cards in her phone and indeed one of the main reasons we purchased this model was because of the dual SIM feature, which allows both work and private use in the same handset. I don't use two SIMs so perhaps it was her use of dual SIMs that was causing the screen "freezing" problems in her phone?

After swapping the phones, she no longer had problems but now I was experiencing the screen "freezes", so it was definitely the phone that was causing the problem and nothing to do with running two SIM cards. Because I mainly use my phone for business, we swapped them back while I looked into possible causes and solutions, something that requires a lot perseverance due to the enormous amount of information posted online in various forums.

One disadvantage was that with newer phones, there is often not much information online but I looked anyway, in case someone else had experienced the same issue. The first place I looked was on the phone manufacturer's website and I downloaded their "link" software, hoping I could use this to install upgrades or troubleshoot potential issues. Strangely though, I couldn't find our specific model listed on the site and that rang a few warning bells far off in the back of my mind.

The downloaded software "talked" to the phone quite happily but informed me that there were no updates

available or required. And that appeared to be about the limit of the functionality of that particular program.

A little more research on the model number, chip version and firmware information took me to forums where people were claiming that the phone was fake and that the manufacturer (and it looked increasingly like it wasn't who we thought it was) had spoofed the hardware ID to make it look like something it wasn't. By that stage, there were more alarm bells going off in my head, only louder this time.

About this time, just before Easter, Nina decided to uninstall an app on the phone because it was persistently downloading unwanted games and other rubbish – the bane of the modern smartphone owner. Strangely, mine didn't do this and we had previously tried using other apps we'd purchased to "freeze" this games app. However, it just seemed to circumvent any attempts at stopping it, which is why she eventually decided to uninstall it. Once it had been uninstalled, the phone immediately rebooted but then got stuck in a loop, with the Android shell crashing then restarting, crashing then restarting and so on.

Did I hear bells again? Yes, and they were lot louder now . . .

Luckily, Easter was coming up and I thought I'd use some of my spare time (that I had intended to use to make a valve amplifier project I'd been planning) to tidy this phone up and get it going again. And so, over Good Friday, I spent many hours on it, initially trying to get it going before eventually resorting to restoring it to its factory settings. It did this OK but unfortunately, when I restarted it, the shell was still crashing, so something else had to be wrong.

Fortunately, I had an identical phone and my reasoning was that I'd find a utility to back up its ROM (ie, the entire operating system and applications) and upload the file into Nina's phone. Problem solved – well, that was the theory anyway.

Rabbit hole

This phone uses a chip-set called "MTK" and some clever person has written a set of tools specifically for phones running this family of processors and has made it freely available for download. Once I had this software, it should then be a simple matter of copying my ROM and then flashing it back to Nina's handset. But of course there was a problem – and this is what I've found when working on phones and tablets; one problem leads to another, then to another and so on until I could barely remember how far down the rabbit hole I had gone.

~I COULD BARELY REMEMBER HOW FAR DOWN THE RABBIT HOLE I HAD GONE.

The problem here was that since we'd had these phones for a couple of weeks before all this started happening, I had swapped the standard Android KitKat bits and pieces that came with the phone with a custom one I'd used before on my old phone. Simply put, this app stores the standard user interface into another folder and replaces it with a new one, so that every time the phone boots it loads the new interface and leaves the old one in storage. I'd also done this with the web browser, SMS/Messaging app, the standard file manager, the screen lock (that bit when you wake the phone up and swipe to unlock) and the phone dialler, replacing them with custom apps with more features.

Initially, I thought that when I "ripped" my ROM to my hard disk, it would pick those custom bits up and take them along too but I was wrong. All went well when I flashed Nina's phone via the USB interface but when it booted, it didn't have a user shell, dialler, SMS, browser or file manager, or any other component that I had customised on my phone. I could pull the "shade" down and access the phone's settings but that was it.

If I'd had a file manager, I could have found and installed the apps I needed but I didn't. And if I'd had a browser, I could have used Google Play to download the apps and install them. But I didn't have any of those things and nor could I get them onto the phone.

No problem, I thought, I'll simply restore my phone to standard, then go through the same process, this time flashing all the right bits and pieces to get things going. The spanner in this theory was that when I restored my phone, it ended up doing the same thing as Nina's! Aaarrgghhh!

By this time, it was Saturday afternoon and I had spent many more hours on this than I should have. What's more, I was further away from a result than ever before. By now, Nina was commenting on the amount of time it was taking and I agreed; I needed to resolve this problem. Unfortunately, Google offered no relief – nobody had any suggestions for the pickle I had got myself into.

I slept on the problem and then spent half of Sunday trying different things, including installing Android's

SDK (application development suite) and using an ADB console (think DOS prompt on Windows machines) to try to "side-install" apps I'd previously downloaded or found on my own phone. I finally got it all connected but every time I tried to install an "apk" file (a standard Android app file), I got an error stating that the "apk" was corrupt and no matter what I did, I couldn't install any apps this way.

By Monday, I was thoroughly sick of it and with two dead phones in front of me, I sat back and took stock. I had a ROM missing some components, so I tried finding software to disassemble and repack the ROM with the right bits. I eventually found such software and repacked the ROM but it wouldn't flash (more error messages and hair pulled out).

And then I realised something; each time I had restored a phone using the MTKDroid tools app, it offered to install a couple of utilities (unfortunately not the kind that would have helped me out), side-loading them via an automatic ADB console. This system worked, so I hit upon the idea of changing the three "apk" files it was installing. Basically, I would get it to install my file manager and web browser "apk" files by renaming them and putting them in the same folder as the MTK "apk" files.

I did this and pressed the upload button and . . . yes! The file manager installed and worked! The web browser failed but when I renamed its files and tried them one at a time, I managed to install a locker, file manager, root browser and web browser and thus could finally download and install the rest of what I needed

By this time, it was 7 o'clock in the evening of Easter Monday. I finally had the job done but when people ask me what I did over Easter, I sheepishly hold my tongue and just say that I had a relaxing weekend!

The phones are working fine now but this episode clearly demonstrates why fixing phones and tablets isn't a viable career move. Aside from the frustrations and the lost time that could have been spent with loved ones, there's no way I could ever charge enough for a job like that. I'll have to find another way.

Industrial machine servicing

Now for something completely different – servicing and refurbishing industrial metal-forming machines. G. S, of Montrose, Tasmania has some interesting stories to tell . . .

In an earlier contribution, I mentioned that I have a small company that designs controls for machines and does factory automation. However, we do get saddled with the odd service job, especially when electricians draw a blank.

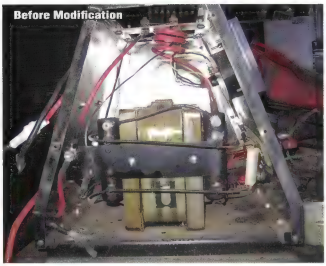
One such case concerns a client I have had for several years. He owns a substantial building products company that makes roofing iron, gutters, fascias and purlins etc. He has fairly old machines that I have managed to keep going by re-building the control gear and he is also lucky enough to employ a fitter who used to work for a metal-forming machinery manufacturer. Between us, we can pretty much get anything working but we get some unusual legacy problems from the previous owners at times.

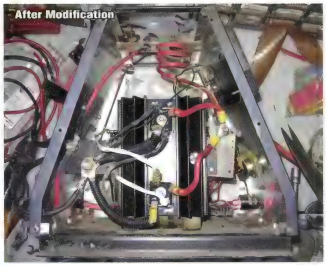
Because my client has a lot of confidence in us, he is always purchasing old machines that other manufacturers were looking to dump. Normally, when a machine reached its use-by date, the owner would purchase a new machine then have the old one cut up and scrapped, to prevent someone getting it running and creating competition. However, because Tasmania is viewed as a foreign land, we are not seen as competition by the mainlanders who are usually only too happy to sell their "junk" to us.

In one instance, I was summoned to look at a "new" panbrake folder. This was a monster that could bend nearly eight metres of 3mm sheet. It also had a hydraulic-powered slitter on its back.

An electrician had hooked it up and it all seemed to run OK. However, when a fold was called for and the apron began to swing, the clamp would open slightly and release the work piece. It turned out that this was why the previous owner had got rid of it. He had had it upgraded to carry the slitter and it had not worked properly since then.

Apparently, he'd had a number of





Modifying & Repairing An Off-Grid Battery Charger

Deciding to fix something rather than simply scrap it is often a gamble, both in terms of time and money. And of course, there's never any guarantee of success. Fortunately, it was a gamble that paid off when J. D. of Dubbo, NSW decided to repair a faulty off-grid battery charger . . .

This story has two aspects: (1) the actual technical challenge of the repair and (2) the vexed question as to whether the item concerned was actually worth saving.

Basically, I have an off-grid system supplying power to my house, or more exactly, two identical systems, with the house wiring split. One system can keep us going at a pinch if necessary. The entire system was installed nearly 20 years ago and has two separate battery chargers (Woods Dialomatic 2440) connected to a generator, so that batteries can be used when it is cloudy for more than a few days.

Both chargers had been faultless until a couple of years ago when they both failed about six months apart. After some troubleshooting, I determined that the problem in each unit was on the mains control circuit board. I then took them to a local technician who replaced the boards (at some cost), after which they again functioned normally.

Although they are nearly 20 years old, they do not see all that much use. In the first year, for example, they operated only about five hours.

Recently, one of them ceased working again and as it was only a year since the repair, I took it back to the technician. A week or so later I got a call to say that they could not repair it, as the parts were no longer available. I called the manufacturer (yes, the units were Australian-made and the company is still manufacturing equipment) and they told me that there were only two parts not available for that model – the transformer and rectifier. And yes, they had just had an enquiry about a rectifier from Dubbo.

Because I was an established customer of theirs, they offered to sell me a current-model replacement charger for just over $1000. Although my chargers are only about 20 years old, the design is actually about 40 years old according to the manufacturer

I picked up my charger from the local technician the following day and he offered a replacement charger, a little smaller and presumably made in China, for $600 or thereabouts. However, for the time being, I decided to see if anything could be done to resurrect the faulty unit. After all, what could be so special about the rectifier?

Once home, I pulled the covers off and examined the unit. The transformer actually has two secondary windings and the rectifier is in fact two separate half-wave rectifiers, each comprising two diodes soldered to 150mm lengths of 19mm-diameter copper pipe. The copper pipes act as heatsinks and the whole lot is assembled onto a fibreglass board.

At least one of the diodes had shorted internally and the resulting heat had melted the solder, disconnecting the diode from its copper pipe and disconnecting the negative battery lead in the process. So it was no wonder that the charger had failed completely. The problem was, how could it be fixed?

After going through the Jaycar catalog, I decided to try using two BR354 35A bridge rectifiers with their outputs paralleled. And to keep them cool, these would be mounted on the largest alloy heatsink that would fit in the available space.

These parts duly arrived and it was then just a matter of assembling everything in the case. This wasn't quite as easy as it sounds though, since very heavy wiring is required throughout. Once the job was finished, the charger was tested and reconnected and it then functioned normally for an entire tank of fuel in the generator.

This repair probably took about four hours of work but that included scratching around in the shed for suitable wire, tags, bolts, etc. I also spent a total of $43 for parts which is considerably less than the replacement cost for the charger.

So why didn't the technician repair it the way I did? I can see a few reasons, including liability, lack of time and warranty issues. However, it does make you wonder just how much equipment gets scrapped when it could be repaired for much less than the cost of replacing it.

people look at it with no result, so in the end he decided to dump it. However, my client heard about it somehow and offered him a few dollars for it. In fact, it actually cost him more to ship it.

Anyway, I watched what it was doing and it looked like the problem was in the PLC (programmable logic controller) program, as it was sending a short pulse to the "open" hydraulic valve on the clamp every time a fold was called for. This made it awkward as I didn't have the tools to program this particular species of PLC. Nor did I feel inclined to spend a heap of money on the programming tools.

This called for some lateral thinking. As the problem only occurred when the apron was asked to swing, the obvious answer was to block the clamp-open valve during the swing. As a result, I added a relay across the apron valve, with its normally closed contact in series with the clamp-open valve.

That solved the problem and the customer was happy with his purchase.

With that job out of the way, I was then asked to take a look at a machine that rolled corrugated roofing. This had been acquired a few years previously and it had been a mess, with the control box containing a rat's nest of oil-soaked wires. Many of these wires did nothing, having been replaced but never pulled out.

At the time, I rebuilt the control box and rewired it. The hydraulics were also replaced so there was not much left to go wrong except the Pegasus electronic controller.

It turned out that this controller was now the problem, as the display was faulty. A cursory glance through the display window revealed that the vacuum fluorescent display was covered in cracks.

After a few "subtle" questions, the machine's operator admitted that the display had been intermittent the past few days and it had blinked out in the middle of a large job. He was under a bit of stress at the time and he took it out on the controller with his fist. It must have been pretty good effort to crack the display though, considering it was behind a thick polycarbonate window.

Fortunately, Pegasus is a good, well-designed (and still manufactured) Australian product, so we were able to get hold of a new display overnight. It is very easy to get into the controller, by removing just four nuts. All the connectors are plug-in and the main PCB can be removed in a couple of minutes.

This reveals the back of the display, which is held in place with a couple of screws. It all fits together with a SIL socket on the main PCB lining up with long SIL pins on the display. A similar arrangement is used to connect the controller's keypad.

The connector on the board was the source of the intermittent display operation. It had loose contacts and vibration from the machine was causing them to go open circuit, usually at inconvenient times. It was a simple matter to replace it.

I then turned my attention to the broken display which was well and truly shattered. It came out easily and I tried to simply drop the new one in place. I found it all lined up OK but it didn't feel right, as it seemed to go down against a hard surface when it should have had some clearance. I removed it and took a closer look with a head magnifier (my eyes are not what they used to be) and found the remains of another display still in place.

It turned out that someone had earlier glued this display directly to the polycarbonate window. When this display was damaged, they chipped out as much as they could and simply put a new one on top of the wreckage, screwing it down tightly and thus giving it no protection against impact.

Using an electrician's hammer and chisel (ie, pliers and screwdriver), I carefully chipped out all the remains. This then allowed the new unit to fit properly and there were no further issues.

Purlin roll formers

Some time after that, my client purchased three Purlin roll formers that allowed him to cover 150, 200 and 250mm sizes and save the ongoing issue of changing dies in the only machine he had. These things run to six figures each but he managed to buy the lot for five figures delivered and "could I get them running?". Getting them so cheap was cause for worry but I said I'd see what could be done.

When I turned up, I was surprised to find two very nice-looking machines that had already been installed, while the third one was under a tarp in the yard waiting for a new building to house it. They were Chinese-made, all built to a common footprint about 12

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

metres long and all using an 18kW hydraulic power pack and a 15kW motor to drive the rollers. This seemed a bit of a waste, as the hydraulic pump could have easily done both jobs. There was also no brake on the machines which I found rather strange.

The control box used a panel PC running a SCADA package. It had nice graphics and a PLC to do the thinking, along with a hefty VSD (variable speed drive) driving the roller motor. All this was housed in a desk console which had spent time in the rain, as no one felt the need to worry about something heading to the scrap yard.

There was no-one to go to for information so I was on my own. It also turned out that the previous owner had given up as he couldn't get a good result from them, even after getting the controls rebuilt locally. This was not looking good.

In fact, this was no longer a service job but a total rebuild. In the end, I designed a control PCB using a Comfile Technologies Cubloc device. This has two high-speed counters and with appropriate I/O is ideal for control jobs like this. It sent serial data to a 250mm Comfile display mounted behind a 6mm polycarbonate window (these are actually touch panels but it's safer to keep fingers [fists!] off them), while the input came from a 16-button Storm keypad.

This was all mounted on the door of a new control enclosure. In addition, this enclosure contained all the necessary bits to run the machine, including a star/delta starter for the hydraulic pump and a new Bonfiglioli VSD for the roller motor.

The VSD was chosen as it has built-in algorithms to operate cranes. These give it the ability to accurately park using electronic and mechanical braking while under heavy load (which I was sure we were going to need). I also added Sick safety lock-outs and emergency stop relays which for some reason the manufacturer failed to fit to the guards.

The theory of operation of a roll former is pretty simple. It punches holes and cuts to length using a counter attached to a device that gives a pulse for every millimetre travelled. Fairly obviously, it has to be accurate.

We rebuilt the first machine, replaced all 62 bearings and fired it up. Apart from the hydraulic hose connections being crossed over, everything did as it should – or so we thought. We ran a test length of four metres and found it was out by 80-plus millimetres. I then adjusted the speed control so that it ran fast but slowed to a crawl when it got to within 100mm of a stopping point.

I also programmed it for impressed current braking which slows the motor quickly by driving high-current DC into the motor for a couple of seconds.

This reduced the discrepancy to 17mm, however subsequent runs gave differing values over and under the target value. We watched the motor and found it still did a lot of revs after the stopping point before coming to a halt, even with DC injection. It also rolled back several revs due to slack in the chain drives and probably the 2-tonne roll of steel strip pulling it back. It was plain that a real motor brake was needed.

An after-market brake was purchased and the fitter made up appropriate adapters. This time the measurements were inaccurate but consistent, so the brake was doing its job.

We now turned our attention to the rotary encoder, which uses a wheel pressed against the strip. This should allow the encoder to deliver one pulse for every millimetre of strip, provided the wheel is the correct diameter. It wasn't so the fitter got to work and produced a wheel that was about as close as was possible with the tools available. This closed the discrepancy to within a few millimetres.

We solved that last discrepancy by using a new encoder manufactured by Sick. This thing is pure genius as it's possible to program the output pulses per rev – up to 10,000. We finished up with 1999 pulses per rev and with a few software tweaks it gave us better than 1mm accuracy in a 10-metre run which was good enough.

As can be imagined, it all took quite a long time to get everything right but the machine now accurately measures and punches. What's more, my client still spent less than half the cost of a new machine while getting a "better than new" machine.

We now have to refurbish the remaining two machines but that's not the end of it. My client has just announced that he's acquired a top hat Purlin roller of the same design. "It's been sitting outside for a while", he told me, "but I reckon you should be able to get it going, don't you think?" SC

Part 2: How to read and understand a PCB manufacturer's technical capability statement

Imagine sending a PCB design to a manufacturer but they ask for some changes to suit their manufacturing capability. How would you feel when these changes take days to implement and disturb your project planning? Extremely frustrating!

Here are some tips to avoid this:

1. If your manufacturer has separate capability statements for prototype and production manufacturing, please ask for a copy and refer to the correct one. It is possible to manufacture small-volume PCBs with tighter tolerances so if you require PCBs in small numbers, you may choose their tightest capability statement.

2. The three basic limitations are:

(a) Etching limitation: (ie, minimum track width/spacing). For 1oz standard finish, 5-6 mil (i.e. 0.127-0.152mm) is the minimum track width and spacing. With special attention, 3.5-4 mil (i.e. 0.089-0.102mm) can be achieved on small to medium volume production. *Thicker* copper can increase the clearance requirements up to 12 or 13mils.

(b) Hole size limitation: Most manufacturers accept finished hole sizes from 0.3mm to 6.35mm as standard. Some manufacturers charge extra for 0.25mm finished holes (standard for QualiEco Circuits). A few manufactures can also accept 0.25mm, 0.2mm or even 0.15mm by paying extra. Holes less than 0.15mm are only possible by laser drilling, which is quite expensive.

(c) Bonding & drilling limitation: (for multilayer PCBs only). Keep in mind the gap between edge of the hole and nearest copper area (track/pad/pour) in inner layers. For multi-layer PCBs, drilling is performed after bonding so this criterion is extremely critical for PCB manufacturers, as is plating tolerance.

3. Minimum copper and solder mask pad size around holes:

(a) Copper pad size – most manufacturers define copper pads around holes as "annular ring". There is a minimum annular ring size you need to maintain everywhere in the design.

(b) Solder mask pad size – a solder mask prevents solder bridges between adjacent pads and traces during soldering process. Most manufacturers define them as "mask openings" which are slightly larger than the pads.

Brought to you by the technical team at QualiEco Circuits Pty Ltd.
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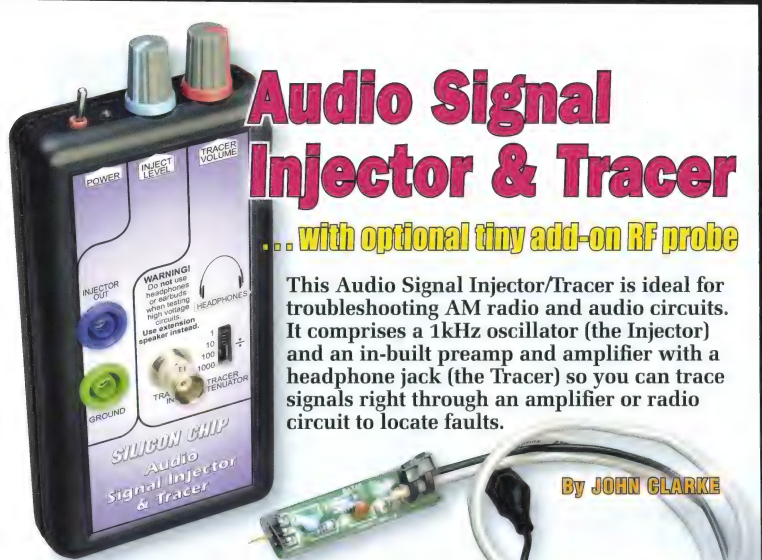
Audio Signal Injector & Tracer

...with optional tiny add-on RF probe

This Audio Signal Injector/Tracer is ideal for troubleshooting AM radio and audio circuits. It comprises a 1kHz oscillator (the Injector) and an in-built preamp and amplifier with a headphone jack (the Tracer) so you can trace signals right through an amplifier or radio circuit to locate faults.

By JOHN CLARKE



This photo shows the complete Audio Signal Injector/Tracer together with its optional RF Demodulator Probe at right.

AT SOME STAGE, everyone involved in electronics will need to find a fault in an audio circuit. It might be a circuit you have just built, a repair job for a friend or a job to be done in your workplace. And while you can often check voltages if you have a circuit diagram, sooner or later you will probably need to trace the progress of an actual signal though the various stages.

For example, you might feed a signal into the input and then find that it disappears as it feeds through a capacitor. The obvious conclusion would be that the capacitor is faulty (open) or it has not been properly soldered into circuit.

To do this sort of fault-finding, you need a suitable signal (one you can hear) and a small amplifier so you can listen to the signal at various stages in the amplifier or AM radio being tested. So our Audio Signal Injector/Tracer has a 1kHz oscillator as the Injector and a small amplifier as the Tracer.

AM radio adds an extra complication because you need to listen to a modulated radio signal as it goes from stage to stage in the circuit. For that you need an optional RF demodulator probe and we show how to build one in the article on page 68 of this issue – it's tiny!

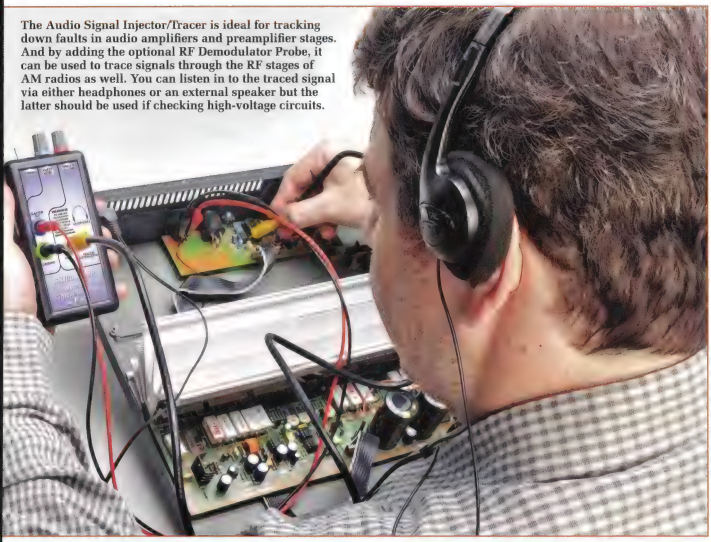
Mind you, if you are repairing an amplifier, you may not need the Injector's audio signal, provided you have a CD player or even a smart phone which has music tracks.

One the other hand, a music signal is not always ideal if you are using an oscilloscope and want to see if the signal becomes distorted at a particular stage in the circuit. In that case, you might find the Injector more convenient as you trace a signal of known shape through the circuit.

As mentioned, our Injector is a 1kHz oscillator and you can see the shape in the accompanying scope grab designated Scope 1. It looks a bit like a sinewave but is actually a somewhat "rounded" square wave. It has a maximum amplitude of about 2V RMS but

Main Features

- Hand held & battery powered
- 1kHz injector output
- Adjustable injector level
- Tracer input attenuator
- Tracer volume control
- Audio output to headphones or small speaker
- Low battery indication
- Optional RF probe for AM modulation detection



The Audio Signal Injector/Tracer is ideal for tracking down faults in audio amplifiers and preamplifier stages. And by adding the optional RF Demodulator Probe, it can be used to trace signals through the RF stages of AM radios as well. You can listen in to the traced signal via either headphones or an external speaker but the latter should be used if checking high-voltage circuits.

it can be adjusted down to just few millivolts.

This means that it will cover virtually all signal tracing situations, from sensitive audio preamplifiers and the audio sections of AM/FM radios, right up to high-powered guitar and public address amplifiers.

Then we come to the Signal Tracer. It needs a small amplifier to listen to small signals in sensitive circuits but it also needs an input attenuator so that it is not overloaded by the much larger signals, perhaps 50V or more, that you might find in a high-powered amplifier. You also need a volume control so that your ears are not blasted as you step through a circuit.

Finally, both the Injector and Signal Tracer need to be protected from any high voltages that may be present in a solid-state or valve circuit. If you feed the Injector into a circuit operating at 300V DC, for example, you don't want it to be blown to shreds and by the same token, if you touch the Tracer probe onto a similar high-voltage point, you don't want it to be "cooked". Our circuit takes care of those possibilities.

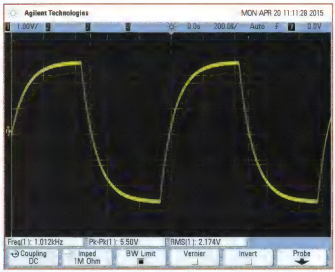
Our Injector/Tracer is housed in a compact plastic case with an internal battery compartment. It has a pair of jack sockets for the output of the Injector and a BNC socket for the input to the Tracer. Next to that socket is a 4-position slide switch for the Attenuator which has settings of 1:1, 1:10, 1:100 and 1:1000.

Specifications

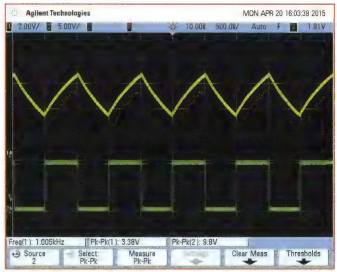
Power: 9V at 2.3mA
Tracer input impedance: ~6.45MΩ to 10MΩ, depending on attenuator setting
Tracer signal gain: adjustable from 2x to 20x
Tracer attenuator: 1:1, 1:10, 1:100 & 1:1000
Tracer signal frequency response: 70Hz to 3kHz
Injector signal: 1kHz rounded square-wave
Injector signal level: adjustable from 0-2V RMS (5.6V peak-peak) with a 9V supply
Headphone output: 6.6V peak-peak maximum into 16Ω with a 9V supply
Test circuit DC voltage: ±300V DC maximum recommended

Input impedance

The input impedance of the Tracer is rather high, varying between about 10MΩ and 6.45MΩ, depending on the setting of the input attenuator. This means that the impedance of the Tracer



Scope 1: the 1kHz waveform generated by the oscillator looks a bit like a sinewave but is actually a "rounded" square wave. It has a maximum amplitude of about 2V RMS but can be adjusted down to just a few millivolts.



Scope 2: this scope grab shows the Schmitt trigger operation of IC1a. The yellow trace shows the charging and discharging of the 6.8nF capacitor from 3V to 6V etc, while the green trace shows the resultant square-wave output at pin 1.

will not load down or affect the operation of the circuit being tested. The high-impedance input also means that the Tracer probe can be used to directly test ceramic (crystal) phono cartridges or piezoelectric pick-ups on musical instruments such as a violins.

To connect signal to the Tracer you can use a 1:1 oscilloscope probe or any shielded cable with a BNC plug at one end and a suitable connector at the other, such as an RCA plug or a pair of alligator clips. More about this later in the article.

The on/off switch, a power LED and the two knobs for the Injector level and Tracer volume controls are at one end of the case while the 3.5mm headphone jack is on the side, adjacent to the 4-position Attenuator switch.

Warning!

When using the Audio Signal Injector/Tracer with high-voltage circuitry (eg, in a valve radio), take care not to touch any part of the circuit with your hand. Always treat the circuit as though it has mains voltage present.

As stated in the article, use a small extension speaker rather than headphones when using the unit with high-voltage circuitry. Small non-powered extension speakers are available for use with iPods and similar MP3/MP4 players.

The use of a small speaker will remove the possibility of deafening clicks or even a high-voltage shock should there be a fault within the Audio Signal Injector/Tracer or if the earth lead becomes disconnected.

Circuit description

Let's now take a look at the circuit of the Audio Signal Injector/Tracer – see Fig.1.

As shown, it's based on an LMC6482AIN CMOS dual rail-to-rail op amp and a handful of other components. One op amp is used for the Signal Injector while the other is used for the Tracer. The output frequency of 1kHz is set by the 100kΩ resistor and 6.8nF capacitor connected to pin 2, the non-inverting input.

The three resistors connected to the pin 3 inverting input set the threshold voltage (at pin 3) at 1/3Vcc or 2/3Vcc, depending on whether the output of IC1a is high or low. So with Vcc = 9V, the input (threshold) voltage at pin 3 will be either +3V or +6V.

When power is applied to the circuit, the 6.8nF capacitor at pin 2 will be discharged (ie, 0V), so pin 2 will be lower than pin 3. Therefore the output at pin 1 will be high (+9V) and this charges the 6.8nF capacitor via the 100kΩ resistor between pins 1 & 2. When the capacitor voltage rises just above 6V, pin 2 becomes higher than pin 3 and so the op amp's pin 1 output switches low, to 0V (remember, this is a "rail-to-rail" op amp).

So now pin 3 is at 3V and the capacitor discharges via its 100kΩ resistor until pin 2 is just below pin 3, whereupon the pin 1 output goes high again to recharge the capacitor. This continuing cycle generates a 1kHz square wave which is filtered using a 6.8kΩ resistor and 22nF capacitor to give a "rounded" waveform, as shown in Scope 1.

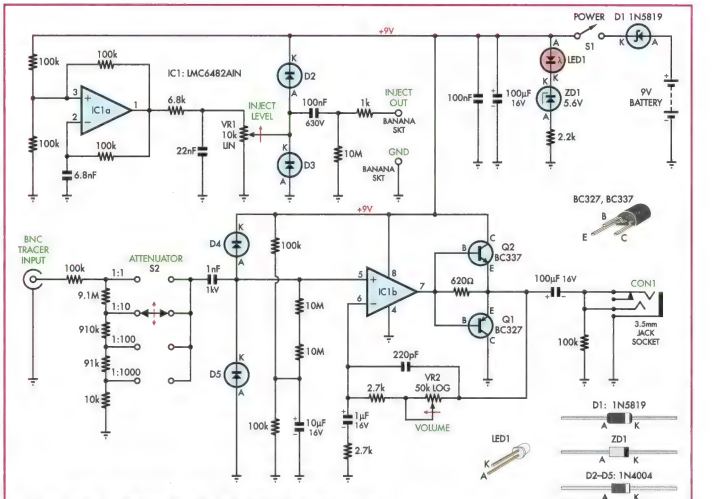
The Schmitt trigger operation of IC1a is demonstrated in Scope 2, which shows the charging and discharging of the 6.8nF capacitor from 3V to 6V etc in the yellow trace. The lower green trace shows the resultant square-wave output at pin 1. Note that the amplitude of the square-wave is shown as 9.8V – we used a fresh 9V battery.

Potentiometer VR1 connects across the 22nF capacitor to provide the Injector level control. This is AC-coupled to the output terminal via a 100nF 630V capacitor. We specified a high voltage rating for this capacitor so that the Injector output can be connected to a high voltage on the circuit under test without damage.

For the same reason, diodes D2 & D3 clamp any high voltage from an external circuit (eg, a valve radio being tested) at the wiper of VR1 to 0.7V above or below the 9V and 0V supply rails. The 10MΩ resistor across the 100nF capacitor is there to discharge the capacitor when it is disconnected from the circuit under test. The 1kΩ resistor in series with the Injector output limits peak current to the clamping diodes.

Tracer circuit

The input signal from the BNC sock-



AUDIO SIGNAL INJECTOR & TRACER

Fig.1: the circuit is based on dual op amp IC1. IC1a operates as a Schmitt trigger oscillator and this generates the injector signal, with VR1 setting the output level. The traced signal is fed in via a switched attenuator and then fed to op amp IC1b. Its output signal is then buffered by Q1 & Q2 and fed to CON 1, while VR2 sets the op amp gain.

et is fed to 4-way slider switch, S2 and the attenuator resistors. The resistors provide for division ratios of 1:1, 1:10, 1:100 and 1:1000.

Following S2, the signal is coupled via a 1nF 1kV ceramic capacitor to the pin 5 non-inverting input of IC1b. This is tied via two series-connected 10MΩ resistors to a voltage divider (two 100kΩ resistors) which provides a reference at 4.5V ie, half the 9V supply.

Diodes D4 & D5 clamp any high voltage input signals to 0.6V above or below the 9V supply rails.

IC1b is connected as a non-inverting amplifier and its pin 7 output drives a complementary emitter follower stage using transistors Q1 & Q2. These provide a buffered output to the headphone socket via a 100µF coupling capacitor.

Note that the emitter follower output stage is operated with no quiescent current but is within the negative feedback loop of the op amp to minimise crossover distortion.

The 50kΩ volume control (VR2) is also in the op amp's feedback loop, connected in series with a 2.7kΩ resistor. In conjunction with the 1µF capacitor and series 2.7kΩ resistor from pin 6 to 0V, this allows the AC gain to be varied from between two and 20. The DC gain is unity, by virtue of the 1µF capacitor.

Note that while the amplifier is mainly intended to drive headphones, it can also be used to drive a small speaker and we recommend this if you are doing signal tracing in a high-voltage circuit which might cause deafening clicks when you touch the probe on high voltage points.

Power supply

As already noted, the circuit operates from a 9V battery, fed in via toggle switch S1. Diode D1 gives protection if the battery is inadvertently connected the wrong way around. A high-intensity red LED is used for power indication. It is bright when the supply is at 9V but drops to a dim glow when the battery is flat, by virtue of ZD1, a 5.6V zener diode in series with the LED.

When the battery is fresh, ie, putting out 9V or maybe as much as 10V, we will have 1.8V across the red LED, 5.6V across ZD1 and 1.6V or more across the 1kΩ resistor so that 1.6mA or more flows through LED1. As the voltage falls, the voltage across the 1kΩ resistor also falls. At a battery voltage of 7.4V or less, there is very little voltage across the 1kΩ resistor and so LED1 will be dim.

RF demodulator probe

As previously noted, if you want

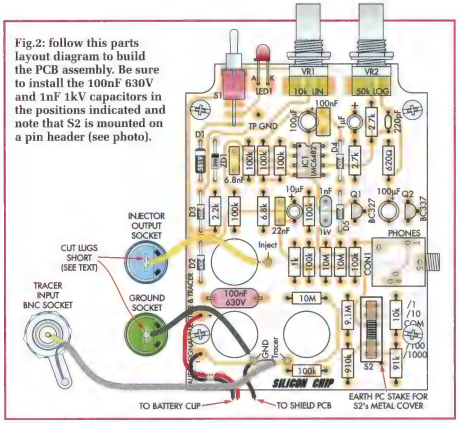
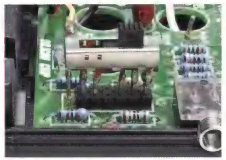


Fig.2: follow this parts layout diagram to build the PCB assembly. Be sure to install the 100nF 630V and 1nF 1kV capacitors in the positions indicated and note that S2 is mounted on a pin header (see photo).



This photo shows how switch S2 is mounted. It's soldered to a pin header so that its top metal face is 12.5mm above the PCB.

to troubleshoot an AM radio with the Tracer, you need to have an additional demodulator probe for the amplitude-modulated (AM) RF signals that should be present in the circuit being tested. As stated, a suitable RF demodulator probe is described on page 68 of this issue.

Construction

The Audio Signal Injector/Tracer is built on a double-sided PCB coded 04106151 (85 x 63mm). This is housed in a plastic remote control case measuring 135 x 70 x 24mm. A panel label measuring 114 x 50mm is attached to the front of the case.

To make the assembly easy, the PCB is designed to mount onto the integral mounting bushes within the case. The top of the PCB is also shaped to fit around the case mounting pillars at that end – see Fig.2 and photo.

Fig.2 shows the parts layout on the PCB. Begin by the installing the resistors. Table 1 shows the resistor colour codes but it's also a good idea to check each one with a digital multimeter before soldering it to the PCB.

The diodes can go in next. Note that there are two different types – D1 is a 1N5819, while D2-D5 are 1N4004s. Be sure to mount them with the correct polarity, then install zener diode ZD1, again taking care with its polarity.

The seven PC stakes can now be fitted. These are installed at the five external wiring points, at TP GND (near LED1) and at the bottom right of S2. IC1 can then be soldered in place. Do not use a socket for this IC, as this would exacerbate noise pick-up.

Installing switch S2

Switch S2 does not mount directly onto the PCB but is instead raised off the PCB using a 6-way DIL pin header. Before installing this DIL header, remove a pin from each side so that there are three pins, then a gap, then two pins (ie, on each side of the header to correspond with the switch pins).

That done, position the header on the PCB with the longer pins facing upwards, then push each pin down so that it extends only 5mm above the top of the PCB. The pins on the underside

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
22nF	0.022µF	22n	223
6.8nF	0.0068µF	6n8	682
1nF	0.001µF	1n	102
220pF	NA	220p	221

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	10MΩ	brown black blue brown	brown black black green brown
❑	1	9.1MΩ	white brown green brown	white brown black yellow brown
❑	1	910kΩ	white brown yellow brown	white brown black orange brown
❑	8	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	91kΩ	white brown orange brown	white brown black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	2	2.7kΩ	red violet red brown	red violet black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	620Ω	blue red brown brown	blue red black black brown

can then be soldered to their respective pads, making sure that the header itself is flush against the PCB.

Once it's in position, switch S2 can be mounted by soldering its pins to the top of the header pins, so that its top metal face sits 12.5mm above the PCB (see photo). The best way to do this is to lightly tack-solder two diagonally-opposite pins first, then make any necessary adjustment before soldering the remaining pins. Don't forget to resolder the first two pins, to ensure reliable connections.

Once it's in position, the adjacent earth PC stake is soldered to the earth tag on S2's metal cover.

Completing the PCB

Now for the capacitors. **Install the 100nF 630V polyester and 1nF 1kV ceramic capacitors in the positions shown,** then install the remaining MKT polyester types. The electrolytics can then go in, taking care to fit each one with the polarity as indicated on Fig.2. Note that the tops of the electrolytics must be no more than 12.5mm above the PCB, otherwise you will not be able to fit the case lid later on.

Follow with potentiometers VR1 & VR2, toggle switch S1 and the 3.5mm socket. VR1 is a 10kΩ linear potentiometer while VR2 is a 50kΩ log potentiometer, so don't get them mixed up. LED1 can then be installed – it mounts horizontally with its leads bent down through 90° exactly 7mm from its lens, so that they go through the PCB pads. Push it down so that its horizontal lead sections sit exactly 6mm above the PCB (use a 6mm-wide cardboard spacer) and check that it is correctly orientated before soldering it to the PCB.

That completes the PCB assembly. It can now be checked and placed to one side while the case is drilled.

Preparing the case

Figs.3 & 4 show drilling templates for the front panel and for the top of the case. They can either be photocopied from the magazine or downloaded as PDF files from the SILICON CHIP website and printed out.

It's just a matter of cutting the templates out, temporarily attaching them to the case panels and then drilling the various holes. The top of the case requires holes for potentiometers VR1 & VR2, switch S1 and LED1, while the front panel is drilled to accept the two banana sockets, the BNC socket and slide switch S2.

The rectangular cut-out for S2 is best made by drilling a row of holes inside the cut-out area, joining these and then filing the job to shape. The two banana socket holes can simply be drilled and reamed to size but the BNC socket hole needs to be shaped as shown on the template. It can be made by first drilling a small hole in the centre, then finalising its shape using small files, with the flat side positioned as shown.

A hole must also be cut in one side of the case to accept the 3.5mm jack socket. To do this, temporarily position the PCB in the case, mark out the socket position, then remove the board and make a semi-circular notch in the base using a small round file. Once that's been done, temporarily assemble the case and complete the hole by filing a matching semi-circular cut-out in the lid.

Finally, you have to remove an internal pillar inside the case lid so that it doesn't foul the nut for the earth banana socket. This can be done using side cutters. Note also that, as provided, the banana socket terminals are too long for the case and have to be shortened by 5mm. A fine-tooth hacksaw blade is the best tool for this job – do not bend the terminals, as they will break. File off any sharp edges after cutting them to length.

Having drilled all the holes, the front panel label can be attached. This can be downloaded from the SILICON CHIP website, printed out (preferably onto photo paper) and affixed to the lid using either glue or neutral-cure silicone.

Alternatively, for a more rugged label, print it out as a mirror image onto clear overhead projector film (be sure to use film that suits your printer), so that the printed side will be on the back of the film when the label is affixed. The film will have to be attached using a light-coloured silicone applied evenly over the surface, as the lid is black.

Another option is to print the panel onto either an A4-size "Dataflex" sticky label (for ink-jet printers) or a "Datapol" sticky label (for laser printers) and directly attach this to the case lid. These labels are available from http://www.blanklabels.com.au and sample sheets are available on request to test in your printer.

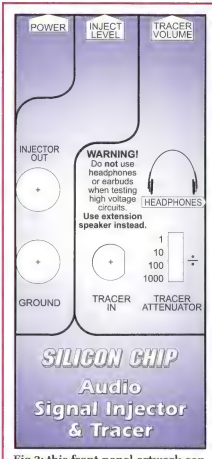


Fig.3: this front-panel artwork can be copied or downloaded from the SILICON CHIP website and used as a drilling template.

Fig.4: the end panel drilling template. Drill pilot holes first to ensure they are accurately positioned, then carefully enlarge them to size.

Once the label is in position, cut out the holes using a sharp hobby knife.

Making a shield PCB

Since the tracer has such a high input impedance, it has the potential to pick up hum from transformers but it will also pick up the injector signal as well, due to direct radiation of the injector signal into the input attenuator and other components in the op amp's input circuitry.

We can reduce this by a significant amount by installing a small shield board, made from copper laminate, underneath the PCB, with its copper side earthed to the PCB's GND stake. The dimensions of this shield board are shown in Fig.5. It fits between the

Parts List

1 remote control case, 135 x 70 x 24mm (Jaycar HB-5610)
1 double-sided PCB, code 04106151, 85 x 63mm
1 single-sided shield PCB, code 04106153, 62 x 63mm
1 panel label, 114 x 50mm
1 9mm square PCB-mount 10kΩ linear potentiometer (VR1)
1 9mm square PCB-mount 50kΩ log potentiometer (VR2)
1 SPDT PCB-mount toggle switch (Altronics S1421) (S1)
1 DP4T PCB-mount slider switch (TE Connectivity STS2400PC04) (element14 Cat. 1291137) (S2)
1 PCB-mount 3.5mm stereo jack socket (CON1)
2 knobs to suit VR1 & VR2
1 panel-mount BNC socket
1 blue insulated banana socket (Jaycar PS-0423)
1 green insulated banana socket (Jaycar PS-0422)
1 9V alkaline battery
1 9V battery snap connector
4 No.4 x 6mm self-tapping screws
7 PC stakes
1 DIL 6-way pin header
1 150mm length of hookup wire
1 50mm length of single core shielded wire

Semiconductors

1 LMC6482AIN dual CMOS op amp (IC1)
1 3mm high-intensity red LED (LED1)
1 BC327 PNP transistor (Q1)
1 BC337 NPN transistor (Q2)
1 5.6V 1W zener diode (ZD1)
1 1N5819 Schottky diode (D1)
4 1N4004 diodes (D2-D5)

Capacitors

2 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 1µF 16V PC electrolytic
1 100nF 630V polyester
1 100nF 63V or 100V MKT polyester
1 22nF 63V or 100V MKT polyester
1 6.8nF 63V or 100V MKT polyester
1 1nF 1kV ceramic
1 220pF disc ceramic

Resistors (0.25W, 1%)

3 10MΩ 1 6.8kΩ
1 9.1MΩ 2 2.7kΩ
1 910kΩ 1 2.2kΩ
8 100kΩ 1 1kΩ
1 91kΩ 1 620Ω
1 10kΩ

Test Leads

Tracer In

Option 1: 1 x 1:1 oscilloscope probe

Option 2: 1 x BNC plug-to-RCA plug lead fitted with a PC stake and 5mm & 10mm heatshrink tubing (see text)

Option 3: 1 x BNC line plug, 1 x RCA line plug, 1 x 500mm-length of single core shielded audio cable, 1 x M4 nut, 1 x PC stake and 2mm, 5mm & 10mm heatshrink tubing (see text)

Injector Out

Option 1: 1 x multimeter lead set with accessory alligator clips

Option 2: 1 x red banana plug, 1 x black banana plug, 1 x red alligator clip, 1 x black alligator clip, 1 x 500mm length of red medium-duty hookup wire, 1 x 500mm length of black medium-duty hookup wire (made into two banana plug to alligator clip leads).

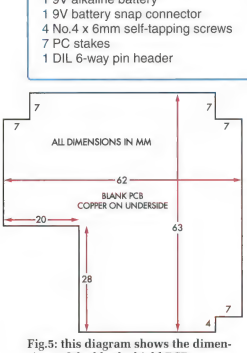


Fig.5: this diagram shows the dimensions of the blank shield PCB.

four integral pillars used to mount the PCB and it has a cut-out to clear the back of the Injector jack sockets.

Alternatively, if you don't wish make your own shield board, you can buy a ready-made board from the SILICON CHIP Online Shop (code 04106153).

The shield board is installed in the case with its copper side facing downwards, away from the underside of the PCB (otherwise it would short the component pigtails!). Before doing this, solder a short piece of wire to the copper side and then connect its other end to the earth pin (GND) for the BNC connection, on the PCB. The shield PCB is then secured inside the case using silicone adhesive.

Final assembly

Now for the final assembly. First, attach the sockets to the front panel, then solder short lengths of hook-up wire to the Inject and GND terminals on the underside of the PCB. That done, pass these leads up through their respective holes in the PCB, ready to solder to the banana socket terminals.

Next, attached a short shielded cable (for the BNC socket) to the GND and Tracer PC stakes on the top of the PCB. The 9V battery snap can then be fitted. Its leads are fed through from the battery compartment before being looped through stress relieving holes in the PCB and soldered to the "+" and "–" terminals.

The next step is to fit the end panel to the potentiometers, switch and LED and install this into the base of the case. The PCB is then secured using four No.4 x 6mm self-tapping screws that go into integral mounting pillars.

Once it's in place, complete the wiring to the banana sockets and the BNC socket, then secure the lid to the base using the supplied screws. **You will need to make sure that the wires do not interfere with the banana sockets – if they are sandwiched beneath the banana sockets, they will prevent the lid from fully closing.**

Similarly, any wires running over the battery compartment or over the slider switch will prevent the case from closing. If necessary, move the wires out of the way using a small screwdriver as the case is being closed.

Finally, fit the battery and the assembly is complete.

Test leads

As mentioned earlier, a 1:1 oscilloscope probe makes a suitable test lead for the Audio Signal Injector/Tracer's BNC input. Alternatively, a cheaper test probe can be made using a BNC-to-RCA lead. This can be a commercial lead but these tend to be made from stiff large-diameter cable.

A do-it-yourself cable using a line RCA plug, a line BNC plug and standard shielded audio cable will be much more flexible. The connections to the

The shield board is installed in the case with its copper side facing down and is secured in place using silicone adhesive. Its copper side is connected to the GND stake on the main PCB.

This is the view inside the completed unit. Make sure that the wiring leads to the banana sockets aren't squashed under them as the lid is closed (push the leads towards the outer edge of each hole using a small screwdriver).

BNC plug can be made using the method described in the article on the RF Demodulator Probe.

The tip of the RCA plug can be used as the probe but note that the outer metal earth shell must be insulated using 10mm-diameter heatshrink tubing to prevent it making contact with the circuit under test. In addition, a PC stake can be soldered to the centre pin of the RCA plug to extend it. That's done by first drilling a 1mm hole in the end of the plug's tip, then inserting the PC stake and soldering it.

It's a good idea to cover the RCA plug's centre terminal with 5mm diameter heatshrink tubing, leaving only the PC stake "probe" exposed. This will help prevent inadvertent shorts when probing closely-packed circuits.

The injector signal can be fed out using a multimeter probe. Alternatively, you can use a lead fitted with a banana plug at one end and an alligator clip lead at the other. A banana plug-to-alligator clip lead can also be used for the ground lead.

Testing

To check that the unit is working correctly, connect the "Injector Out" signal to the "Tracer In" (BNC) socket, then plug in headphones (or earphones) and listen for the 1kHz signal. Assuming that it's present, check that the level varies when the "Inject Level" potentiometer, the "Tracer Volume" potentiometer and the "Tracer Attenuator" switch are adjusted.

As noted above, if the tracer input is disconnected from a circuit, the unit will pick up hum and the 1kHz injector signal due to the tracer circuit's high input impedance (ie, the 1kHz signal will be heard even when there is no connection). The pick-up level will depend on the capacitance of the input cable, the attenuator setting (S2), the injector level setting (VR1) and the gain (Volume) setting (VR2).

Obviously, it will be at a maximum when the attenuator is set to 1:1 and VR1 & VR2 are at maximum but this combination of settings would not be used in practice. Basically, it's just a matter of choosing settings to suit the job at hand and to minimise extraneous noise pick-up.

Under normal use and when connected to a circuit for testing, the crosstalk from the injector will be minimal and will be swamped by the signal from the circuit under test.

Ground connections

Finally, note that when using the Audio Signal Injector/Tracer, the Ground banana socket must be connected to the ground of the circuit under test. This can be done using a lead fitted with an alligator clip as described above or by using the earth lead on the 1:1 oscilloscope probe.

Now turn to page 68 for the optional RF Demodulator Probe. SC

By JOHN CLARKE

Simple unit uses just a handful of parts . . .

AM RF Demodulator Probe For Signal Tracers

If you want to troubleshoot an AM radio with the Signal Tracer/ Injector described in this issue, you need a demodulator probe to detect the amplitude-modulated RF signals that should be present in the circuit being tested. This one is compact and easy to build.

Fig.1 shows the circuit details of the RF Demodulator Probe. It uses a fast BAT46 Schottky diode (D1) as the detector and its output is filtered with a 1nF capacitor to remove the RF signal, leaving the audio modulation which can then be fed to the Tracer.

The audio frequency response of the probe is about -3dB down at 1.6kHz, as set by the 1nF capacitor and associated 100kΩ resistor. Since the RF probe is intended for use in valve AM radios, its 100pF capacitor is a 1kV rated ceramic type.

Note that the probe is a passive device and requires no external power.

Construction

The RF probe is built on a PCB coded 04106152 (45 x 11mm) – see Fig.2. Install the two 100kΩ resistors and the two capacitors first, followed by the diode. Check that the diode is correctly orientated (ie, banded end towards the right).

The probe tip is made using a 3-way right-angle pin header. Solder this in place and then cut the outer two pins flush with the end of the PCB, leaving just the centre pin.

PC stakes are used to terminate the three external wiring connections. Fit these to the PCB, then attach the earth wire to the GND stake and the shielded cable to the SIG and GND terminals. The shielded wire and the earth wire are then secured to the PCB using two cable ties.

Once all the parts are in place, the assembly is covered in a 55mm length of 16mm-diameter heatshrink tubing that's shrunk down with a heat-gun.

The far end of the earth lead can

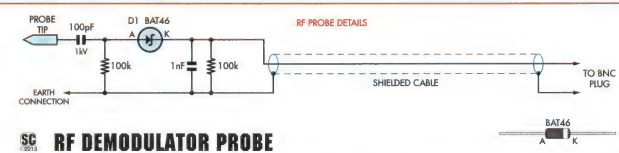


Fig.1: the circuit uses a BAT46 Schottky diode (D1) as the detector plus a 1nF capacitor to filter out the RF signal. The 100pF 1kV input capacitor blocks DC signals, while the 100kΩ resistor sets the frequency response to -3dB at 1.6kHz.

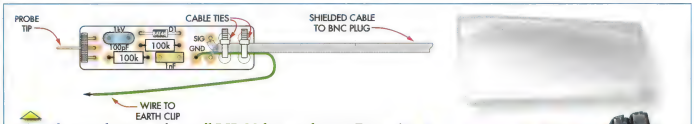


Fig.2: the parts layout on the small PCB. Make sure the 100pF capacitor is rated at 1kV and take care with the orientation of Schottky diode D1. The photo at right shows the completed PCB before the heatshink sleeve was fitted.

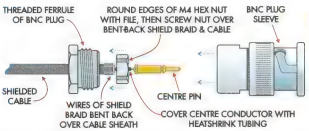


Fig.3: this diagram shows how the shielded audio cable is connected to the BNC plug (see text).

be terminated in an alligator clip or a hook clip, while the shielded cable goes to the BNC plug. Note that this type of plug is designed for use with a larger-diameter shielded cable than the shielded audio cable used here. However, a satisfactory connection can be made if an M4 metal nut is used as part of the assembly hardware.

Fig.3 shows the details. The first step is to file the six corners off the M4 nut, so that it will fit into the back of the BNC plug. Once that's done, strip the outer insulation and the centre wire insulation as shown in Fig.3 and solder the centre wire to the BNC socket's centre pin.

Next, bend the shield wires back along the cable and twist the M4 nut on over these wires. A short length of 2mm-diameter heatshrink tubing is then used to cover (and stiffen) the centre wire before it meets the centre pin, after which the plug sleeve can be fitted and the threaded ferrule tightened to secure the assembly.

Finally, the wire can secured inside the threaded ferrule using neutral-cure silicone sealant. SC

RF Probe Parts List

1 PCB, code 04106152, 45 x 11mm
1 BNC line plug
1 right-angle 3-way SIL header
1 500mm-length of single core shielded wire
1 black alligator clip
1 300mm-length of black hook-up wire
1 BAT46 Schottky diode (D1)
1 1nF MKT polyester or ceramic capacitor
1 100pF 1kV ceramic capacitor
2 100kΩ 0.25W resistors
2 100mm cable ties
1 M4 metal nut
3 PC stakes
1 55mm-length of 15mm-diameter heatshrink tubing
1 5mm-length of 2mm-diameter heatshrink tubing

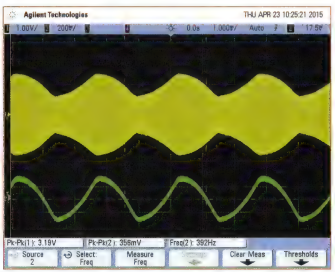


Fig.3: the yellow trace in this scope grab shows a 1MHz carrier from an old Leader signal generator, amplitude modulated with a 400Hz audio signal. The modulation depth is about 30%. The green trace shows the 400Hz (actually 392Hz) audio modulation from the RF probe. Note that the recovered modulation is a somewhat distorted sinewave.

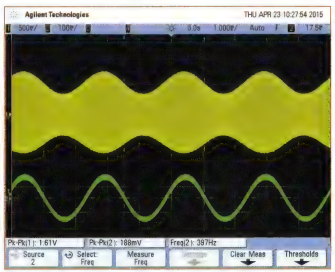


Fig.4: the yellow trace in this scope grab shows a 1MHz carrier from an old Marconi signal generator, amplitude modulated with a 400Hz audio signal. The modulation depth is about 30%. The green trace shows the 400Hz (actually 397Hz) sinewave audio modulation from the RF probe.

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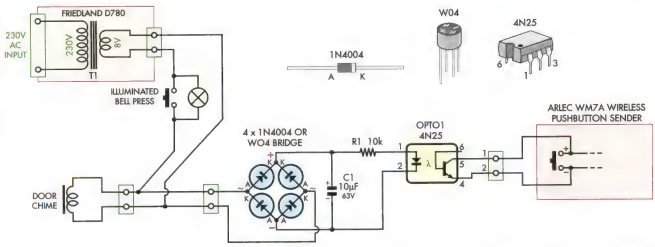
Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Wireless door chime repeater

There are lots of situations where the standard domestic front door bell can't be heard by the home's occupants. You might be in the garden, in the shed or you might have a hearing problem.

This Wireless Door Chime Repeater uses a bridge rectifier connected across an existing low-voltage door chime and each time the doorbell switch is pressed, the AC voltage across the Door Chime solenoid drives the bridge rectifier and the LED inside an optocoupler to trigger one or more wireless door chimes. These units can be located as required or carried around by the resident if they have a hearing problem.

Capacitor C1 acts to damp the voltage spike from the bell, buzzer or gong solenoid's inductance. It also prevents phantom rings by filtering any stray pulses or RF pickup on the front door bell wiring.

The prototype was built around an Arlec DC322 Series 3 Door Chime. The wireless bell press uses a WM7A PCB, with the press switch contacts applying around 3V to the gate of a small surface-mount Mosfet. The four mounting pins of the switch project through to the top of the PCB. Use a multimeter to determine the switch contacts, then solder a couple of wires to the appropriate switch pins and connect them to the output transistor of the optocoupler.

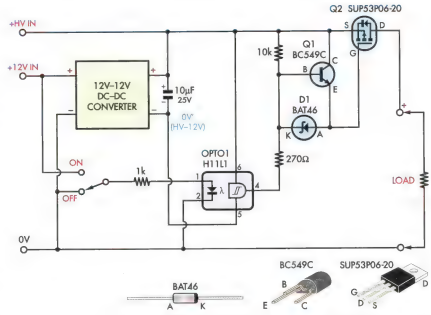
Roger Forsey,
Seaholme, Vic. ($35)

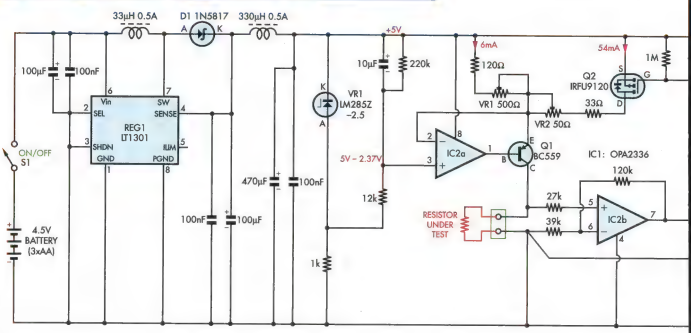
High-side Mosfet switch with optocoupler control

There are a number of high-side Mosfet driver ICs but this circuit takes a discrete approach, with an optocoupler used to isolate a low voltage (12V) switching signal from the gate of a P-channel Mosfet.

To briefly explain, most Mosfet switching circuits use an N-channel Mosfet as a "low side" switch, with the load connected between the positive DC rail and the Mosfet's drain. However, that configuration does not suit many applications where the load needs to have one side connected to the low voltage

. . . *continued on page 72*





Low ohms meter has LCD

Most digital multimeters tend to have difficulty measuring low values of resistance. With this in mind, this circuit was designed to measure resistance from 0.1Ω to 100Ω and to displays the result on an LCD. This involves feeding the unknown resistance with a constant current source and measuring the voltage drop across it. A PIC micro then calculates the resistance and drives the display.

If you look at the specifications of the PIC16F88 microprocessor, you can see that it has an inbuilt 10-bit analog to digital converter (ADC) and inputs RA2 & RA3 set the voltage range for the ADC. On this circuit RA3 is supplied with +2.5V from an LMZ285-2.5 reference, RA2 is connected to 0V volts and the input is connected to RA4. If you calculate two to the power of 10 (10-bit), the result is 1024. If you now divide 2.5V by 1024, the resolution of the ADC as 2.4 millivolts per step.

If we arrange the rest of the circuit so that when 100Ω is fed with a constant current and the voltage at the input RA4 is 2.44V, then the ADC result will be (2.44 ÷ 2.5) x 1024 ≈ 1000. If you use the same current and change the resistance to 50Ω the ADC will read 500. In other words, the value stored in memory for the ADC result will always be 10x the resistance.

When the resistance is below 10Ω, the microprocessor is programmed to increase the current through the resistor by a factor of 10 which improves the accuracy of the measurement. From the value stored in the ADC, the microprocessor calculates the actual resistance value and sends the parallel data for display on the LCD.

The constant current is provided by op amp IC2a and transistor Q1 and this sets the current to 6mA (for resistors between 10Ω and 100Ω). In this condition, pin 13 of IC1 (RB7) is at +5V which means that Mosfet Q2 is off, so the constant current is provided by 500Ω trimpot VR1 in series with the 150Ω resistor.

As the current is 6mA and the voltage on the positive input of IC1with respect to +5V is -2.37V (obtained from the 2.5V zener diode and the 12kΩ and 100kΩ resistor divider) then the value of the total resistance should equal (2.37 ÷ 6) x 1000 = 395Ω. Hence trimpot VR1 should be set at about 245Ω.

When measuring resistances below 10Ω, Mosfet Q2 turns on and the current is now determined by the 33Ω resistor in series with 50Ω

High-side Mosfet switch

. . . continued from page 71

side of a DC supply while the Mosfet switches in the "high side".

A good example is a motor in a speed control circuit where its frame needs to be connected to the negative DC supply.

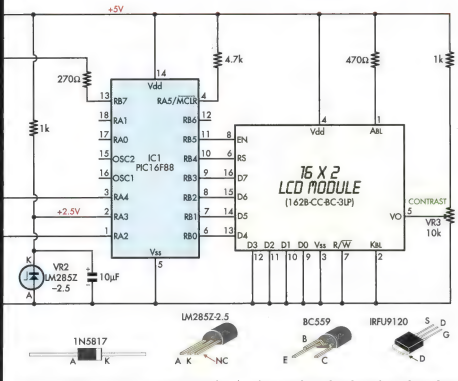
This high side switch circuit has an SUP53P06-20 P-channel Mosfet (Jaycar Cat. ZT-2464) connected to a high-voltage supply and the load is connected between the Mosfet's source and the 0V line of the high voltage supply. Note that there must be full isolation between the inputs and outputs of the DC-DC converter.

Optocoupler OPTO1 provides isolation of the gate control signal of the Mosfet. Switch S1 feeds 12V via a 1kΩ resistor to the internal LED of OPTO1 and this pulls the output at pin 5 down to the 0V line of the floating 12V DC rail.

This pulls down the gate of Q2 via diode D1 and the 270Ω resistor and so Q2 turns on. When OPTO1's pin 4 goes high, the base of transistor Q1 is pulled high, turning it on and thus discharging the gate of Q2 for a faster turn-off.

When fed with a high-speed gate pulse signal, the circuit will happily run to at least 100kHz.

Gregory Freeman,
Mt Barker, SA. ($50)



trimpot VR2, (all in parallel with the 150Ω resistor and trimpot VR1). We know have 6mA flowing though VR1 and VR2 should be set at about 11Ω to provide the additional 54mA.

Op amp IC2b monitors the voltage developed across the resistor under test. It is connected as a non-inverting DC amplifier with a gain of about 4. The OPA2336 is a rail-to-rail CMOS op amp which is needed in this application.

In the case of measuring a 100Ω resistor, the voltage developed across the test resistor will be 0.6V. This is amplified by IC2b and fed to the RA4 input of IC1. This is converted and the result is displayed on the 2-line x 16 character LCD.

The circuit is powered from an LT1301 switchmode step-up regulator which produces +5V from three AA alkaline cells and it will continue to work down to +3V from the cells. To give long battery life, a momentary contact pushbutton is used as the power switch. An additional 330µH inductor is connected in series with the regulator's output to ensure a low hash supply for the sensitive ADC circuit.

When measuring low-value resistors, the resistance of the connecting leads can give rise to an elevated answer as they are in series with the resistor being measured. To overcome this, you need to have two sets of wires connecting to the resistor being measured. One set provides the current and the other set is connected to the input terminals (via the 27kΩ and 39kΩ resistors of IC2b) to measure the voltage.

Les Kerr is this month's winner of a $150 gift voucher from Hare & Forbes

In the prototype, a 3mm shielded audio cable fitted with crocodile clips was used for connecting to the resistor under test. At the crocodile end, both the shield and the centre conductor were connected to the clip. At the other end of the first cable, the shield was connected to 0V and the centre conductor connected to the 39kΩ resistor.

For the second cable, the shield was connected to the collector of Q1 and the centre conductor connected to the 27kΩ resistor. In this way, the shield carries the current and the centre conductors are connected to the voltmeter circuit.

To calibrate the unit, first adjust the trimpots to the values stated above. Then connect an 82Ω 0.1% resistor and adjust trimpot VR1 so that the display reads 82.0Ω. Do the same with an 8.2Ω resistor only this time adjust trimpot VR2 so that the display reads 8.2Ω.

If the resistor is over 100Ω, then the display will read "over range".

The software for the micro, *Low ohms.bas*, can be downloaded from www.siliconchip.com.au

Les Kerr,
Ashby, NSW.

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CHAMPION PREAMP

By LEO SIMPSON

You can use this simple unit as a general-purpose stereo preamp or as a dual-channel preamp, with a microphone for one channel and guitar in the other. One channel can have fixed gain while the other is variable with an on-board trimpot or external potentiometer. Better still, it gives good performance and will work over a wide range of supply voltages.

ARE YOU ONE of the thousands of readers who built our very popular PreChamp preamplifier from the July 1994 issue? This is still very popular and available as a kit but it is only a single-channel unit and its 2-transistor design is quite basic.

With the inexorable march of technology, it is now possible to do much more, in a module which is only a little larger and with the bonus of two channels rather than one. Better still, this 2-channel design draws less current than the PreChamp.

I should state at the outset that this 2-channel preamp is not a brand-new design. It is based on the preamp section of the Champion amplifier module which was featured in the January 2013 issue. The major feature of that article was the tiny AN7511 monolithic amplifier chip which can deliver up to 7W peak power, depending on load and supply voltage. The preamp section might have been seen almost as an afterthought but it would be a pity for it to have passed mostly unnoticed.

Which is partly why we have decided to devote an article just to the preamp; that and the fact that we have recently had a number of requests for preamps which would be neatly answered by this design.

So what is good about it? First, it can use one of two dual rail-to-rail op amps and these have the outstanding feature of maximum output voltage swing. So, for example, if you have a 9V supply rail, the maximum undistorted output voltage can be within a whisker of 9V peak-to-peak; about 8.5V p-p, to be more precise. That is much better than the old PreChamp design and you don't have to tweak the input bias to obtain it.

Another advantage is that the specified rail-to-rail op amps can be designed into a preamp with a very high input impedance. This is highly desirable if you want a preamplifier to suit a ceramic phono cartridge or a piezoelectric pick-up in a musical instrument such as a violin. In both cases, an input impedance of 5MΩ is desirable for good bass response.

Main Features

- 2-channel preamplifier configurable for different inputs
- Low distortion
- Low current drain: 2mA
- Signal-to-noise ratio: –80dB
- Operating voltage range: 6-12V with LP2950CZ-5.0 5V LDO regulator; 12-20V with 78L09 9V regulator

Optional electret microphone

One of the attractions of the PreChamp was that you could install an on-board electret microphone. The only modification required was to add a bias resistor. That feature can also be included in this 2-channel design and you could, in fact, have two electret microphones, although for useful channel separation you would need to install them both on shielded leads.

Circuit details

Let's have a look at the circuit which is similar to but not exactly the same as the preamp in the January 2013 article. Fig.1 shows the details. Both channels are shown and the dual op amp is an LMC6482. Since we are employing a single DC supply rail, we need a half-supply reference from which to bias the inputs of both op amps.

This reference is derived from the supply rail via a voltage divider consisting of two 10kΩ resistors bypassed with a 100μF electrolytic capacitor. We can use such high-value resistors for the divider because the bias current drawn by each input of the op amps is a just a fraction of a picoamp. On the other hand, we want that bypassed half-supply to have quite a low impedance, hence the relatively large capacitor value of 100μF.

Both op amp circuits are identical although it is possible to have different gains in each channel, depending

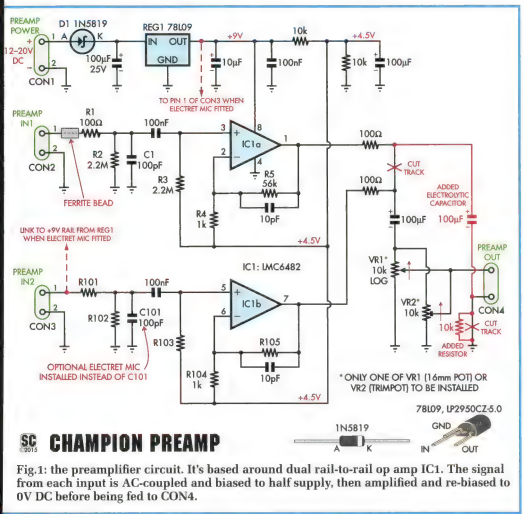


Fig.1: the preamplifier circuit. It's based around dual rail-to-rail op amp IC1. The signal from each input is AC-coupled and biased to half supply, then amplified and re-biased to 0V DC before being fed to CON4.

on your application. For the moment though, let's assume that both are identical and we will just describe channel 1, based on op amp IC1a.

The input signal from CON2 passes through a low-pass filter consisting of a 100Ω resistor (R1) and a small ferrite bead in series, together with a 100pF capacitor connected to the 0V line (C1). This is to attenuate any RF signals that may be picked up by the input leads. There is also a 2.2MΩ resistor to pull the input signal to ground (R2).

If you are going to feed the preamp with an iPod or similar player you will need to use a much lower value of, say, 1kΩ to provide it with sufficient load current. For the moment though, the values we have shown on the circuit for channel 1 are selected to suit the pick-up in an electric guitar.

The signal is then AC-coupled via a 100nF capacitor to pin 3 of IC1a and a 2.2MΩ resistor biases the op amp's input to the half-supply rail. This ensures that the output waveform will swing symmetrically within the supply rails of dual op amp IC1. The two 2.2MΩ resistors on either side of the 100nF AC-coupling capacitor are in parallel as far as the signal source is concerned, setting the unit's input impedance to around 1.1MΩ.

IC1a buffers and amplifies the signal from CON2 while IC1b does the same for the signal from CON3. Gain is set at 57 times (35dB) by the 56kΩ (R5) and 1kΩ (R4) feedback resistors. The 10pF feedback capacitor reduces the gain for high-frequency signals, giving a little extra stability and noise filtering.

Changing the gain

Note that this high gain suits a musical instrument such as a guitar but you can easily increase or reduce the gain to suit by changing the value of R5 and you can change the input impedance as well.

For example, if you want to configure it for a dynamic microphone, R2 & R3 are changed to 100kΩ each to give an input impedance of 50kΩ, while R5 is changed to 100kΩ to give a gain of 101 times (41dB).

If you want to install an electret microphone insert on the PCB, you would install it in place of 100pF capacitor C101. At the same time, R101 is changed to 10kΩ and it provides the bias current for the electret. The other end of the 10kΩ resistor is connected to the positive supply rail, from REG1.

Finally, R102 is omitted, R103 is 220kΩ and the gain is set to 23 (27dB) with R105 being 22kΩ.

Ceramic cartridge

Another interesting application is to use the Champion preamp with a stereo ceramic cartridge (don't laugh; this was a standard fitment on millions of record players and many people are dragging them out to listen to their old record collections). Ceramic cartridges require a high input impedance and this is an easy option with this preamp. Both R2 & R3 are specified at 10MΩ, giving an input impedance of 5MΩ which ensures good bass response.

The gain does not need to be high though and so we can set R5 to 2.7kΩ. This gives a gain of 3.7 (11.3dB). The same configuration can be used for a piezo pick-up on musical instrument such as a violin.

So to summarise, depending on

Table 1: RC Gain Selection Values

Input	Gain	R1/101	C1/101	R2/102	R3/103	R4/104	R5/105
Guitar	57	100Ω	100pF	2.2MΩ	2.2MΩ	1kΩ	56kΩ
Microphone	101	100Ω	100pF	100kΩ	100kΩ	1kΩ	100kΩ
Electret	23	10kΩ*	–	–	220kΩ	1kΩ	22kΩ
MP3	28	100Ω	100pF	1kΩ	220kΩ	1kΩ	27kΩ
Piezo Pick-up	3.7	100Ω	–	10MΩ	10MΩ	1kΩ	2.7kΩ

* Connect one end of this resistor to the +9V rail from REG1.

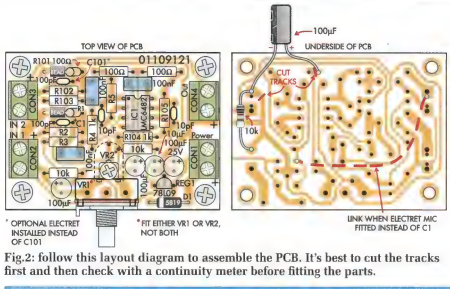


Fig.2: follow this layout diagram to assemble the PCB. It's best to cut the tracks first and then check with a continuity meter before fitting the parts.

Table 2: Resistor Colour Codes

Value	4-Band Code (1%)	5-Band Code (1%)
10MΩ	brown black blue brown	brown black black green brown
2.2MΩ	red red green brown	red red black yellow brown
220kΩ	red red yellow brown	red red black orange brown
100kΩ	brown black yellow brown	brown black black orange brown
56kΩ	green blue orange brown	green blue black red brown
27kΩ	red violet orange brown	red violet black red brown
10kΩ	brown black orange brown	brown black black red brown
2.7kΩ	red violet red brown	red violet black brown brown
1kΩ	brown black red brown	brown black black brown brown
100Ω	brown black brown brown	brown black black black brown

what type of source you are using and the gain required, you can easily obtain the required input impedance and gain. Table 1 shows the values to use.

Two outputs

In the original Champion preamplifier, the outputs of the two op amp stages are mixed using a pair of resistors and then AC-coupled to potentiometer VR1 or VR2, depending on which is installed. In our application, we want two separate outputs and so if an output level control is to be used, it can only affect one channel. As shown on the circuit of Fig.1, the output of IC1b connects to VR1 (or VR2) via a 100Ω resistor and 100µF DC blocking capacitor. The wiper of VR1 then connects to one terminal on CON4.

The output of IC1a is also fed via a 100Ω resistor with a second blocking capacitor and bias resistor added under the board. This output goes to the other terminal on CON4. Note that two track cuts on the PCB need to be made, in order to give this independent two channel operation.

IC1 is powered via a 78L09 low-power 3-terminal 9V regulator, assuming you are using a DC plugpack with an output of 12V or more (up to 20V DC). This regulator is fed from CON1 via Schottky diode D1 which protects against reversed supply polarity.

Note that if you intend using a 9V battery for this project, you may want to employ the LP2950CZ-5.0 5V regulator. No other modifications are required if you make this change but the preamplifier will inevitably have a reduced output voltage swing and therefore a reduced overload margin for strong input signals.

Table 3: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
100pF	NA	100p	101
10pF	NA	10p	10

Construction

You will be using the Champion PCB for this project (code 01109121) and you will need to cut off the section for the AN7511 audio amplifier. Don't discard it – it's a handy little amplifier module in its own right and the AN7511 amplifier chip is quite cheap.

Parts List

1 PCB, code 01109121, 57 x 41mm (see text)
1 PCB-mount electret microphone insert (Jaycar Cat. AM4011) (optional; see text)
1 10kΩ log PCB-mount 16mm potentiometer (VR1) OR
1 10kΩ mini horizontal trimpot (VR2)
2 ferrite beads, Jaycar LF1250
4 mini 2-way terminal blocks (CON1-CON4) (omit one if electret is installed)
1 8-pin DIL socket
4 M3 x 10mm tapped Nylon spacers
4 M3 x 6mm machine screws
1 short length hookup wire (60mm)

Semiconductors

1 LMC6482 or LMC6032 dual op amp (IC1) (eg, Jaycar ZL3482)
1 78L09 or LP2950CZ-5.0 5V LDO regulator (REG1) (eg, Jaycar ZV1645) – see text
1 1N5819 Schottky diode (D1)

Capacitors

1 100µF 25V electrolytic
3 100µF 16V electrolytic
1 10µF 16V electrolytic
3 100nF MMC or MKT
2 100pF ceramic (omit one if electret is installed)
2 10pF ceramic

Resistors (0.25W, 1%)

3 10kΩ 2 100Ω
See Table 1 for R1-R5

Note: Jaycar will be selling a kit of parts for this project – Cat. KC-5531.

The remaining preamplifier PCB measures just 57 x 41mm. It has provision for mounting pillars at its four corners and four 2-way connector blocks. One of those blocks is used as the terminals for the two preamplifier outputs.

Since there are changes to the component layout, this means that you will have to follow the parts layout of Fig.2 and ignore most of the resistor values shown on the screen-printed layout on the PCB itself. You also need to cut the copper tracks of the PCB in two places as shown on Fig.2.

Having cut the tracks, start the assembly by installing the resistors.

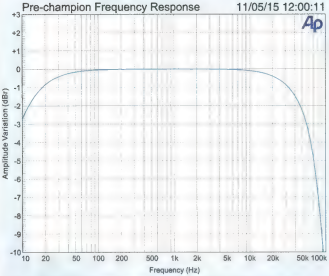


Fig.3: frequency response is within +0,-0.5dB between 30Hz and 20kHz with -3dB points around 8Hz and 55kHz. It's less than 1dB down at 20Hz.

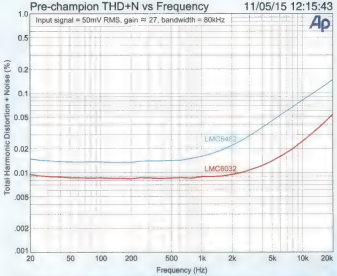
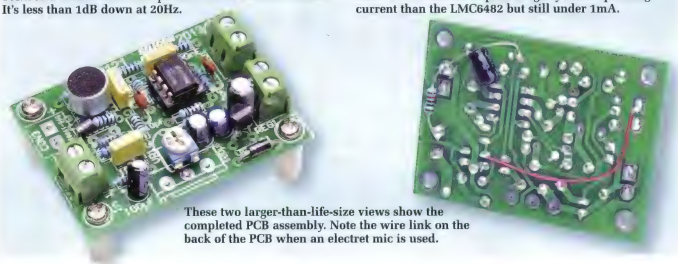


Fig.4: the LMC6032 has about half the noise of the LMC-6482. The LMC6032 requires slightly more operating current than the LMC6482 but still under 1mA.



These two larger-than-life-size views show the completed PCB assembly. Note the wire link on the back of the PCB when an electret mic is used.

You will need to refer to Table 1 for the values for R1-R5 and R101-R105. Table 2 shows the colour codes but it is good idea to check each value with a multimeter before fitting it. A ferrite bead should be slipped over one leg of each 100Ω input resistor, if fitted (ie, R1 & R101).

Follow with diode D1 and then fit the IC socket with its pin 1 notch orientated as shown. Next, fit the 78L09 or LP2950CZ-5.0 regulator, REG1. Follow with the ceramic and monolithic capacitors.

The 2-way terminal blocks are next, each installed with its wire entry holes facing outwards. Note that CON3 is not installed if you have fitted an electret microphone insert for channel 2.

The next step is to decide whether to fit potentiometer VR1 or trimpot VR2. It will only control the output signal level from one channel and you may decide to link it out. You can then fit all the electrolytic capacitors. In each case, the longer lead goes into the hole marked with a "+" sign.

Once those parts are in, fit the M3 x 10mm tapped spacers to the corner mounting positions using M3 x 6mm machine screws.

If you are installing an electret, wire a 10kΩ resistor in the position for R101 and connect the end adjacent to CON3 to the output of the 3-terminal regulator. We show this with a dotted red line on Fig.2. In addition, R102 and C101 are omitted.

If you are going to use only one channel of the preamplifier, it's a good idea to short the unused channel's input to 0V by using a wire link for resistor R1 (or R101) and by shorting the two terminals of CON2 (or CON3).

When you have carefully checked your assembly and soldering against the circuit of Fig.1, Table 1 and the overlay diagram of Fig.2, you are ready to apply power. Check that the output of REG1 is 9V (or close to it) if a 78L09 has been fitted. If an LP2950CZ-5.0 has been fitted, REG1's output should be close to 5V.

Next, turn off the power, insert the op amp (carefully), power back on and then check the DC voltage at pins 1 & 7. In each case, they should be sitting at half supply; 4.5V for a 9V supply and 2.5V for a 5V supply.

Performance

Figs.3 & 4 show the frequency response and total harmonic distortion curves of the preamplifier. Note that of the two op amps we've specified, the LMC6032 gives the best performance but it isn't as easy to get as the more common LMC6482.

To achieve a THD+N this low, the preamp will need to be installed in an earthed metal box. Otherwise, hum and RF pick-up will reduce the signal-to-noise ratio and consequently the total harmonic distortion performance. SC

SPIKE: improved software for the Signal Hound

By JIM ROWE

When we reviewed the Signal Hound USB-SA44B mini spectrum analyser in the October 2014 issue of SILICON CHIP, we were very impressed with the performance of both the hardware and its accompanying software. Now Signal Hound has come up with a greatly enhanced software package to go with the USB-SA44B and their other instruments.

IN OUR ORIGINAL review of the USB-SA44B spectrum analyser, we were particularly impressed with the analyser hardware itself. Inside its compact 77 x 27 x 167mm aluminium case there is an advanced narrow-band SDR receiving system tuning over the range from 1Hz to 4.4GHz and delivering a level of performance that compares very favourably with high-end self-contained spectrum analysers – but at a fraction of their price.

We were also impressed with its software package which controls the USB-SA44B hardware box (and the optional USB-TG44A tracking generator) from your PC as well as accepting, processing and analysing the output data stream from it to produce the analyser's output display and measurements.

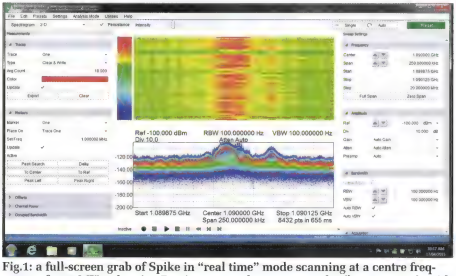


Fig.1: a full-screen grab of Spike in "real time" mode scanning at a centre frequency of 1090MHz, showing Persistence on the spectrum plot (lower centre), with a 2D spectrogram above it.

The software did have a few rough edges but we judged them to be fairly minor and not significant, considering the excellent performance of the USB-SA44B hardware. But early this year Signal Hound released a greatly enhanced version of their software package, renamed "Spike". And in the last three months or so they've released a number of upgraded versions of Spike.

We're reviewing the latest version at the time of writing: Spike 3.06. This is now being provided on the CD accompanying the USB-SA44B and other analysers purchased new. Existing users can download it at no charge from Signal Hound's website at www.signalhound.com/spike

It comes as a zip file which includes its matching USB drivers. A PDF of the User Manual for the new software can also be downloaded from the same website.

Spike 3.06 is compatible not just with the USB-SA44B but also with the rest of the Signal Hound products, including the USB-TG44A tracking generator. There are two versions, compatible with the 32-bit or 64-bit versions of either Windows 7, 8 or 8.1.

Note that although the Spike soft-

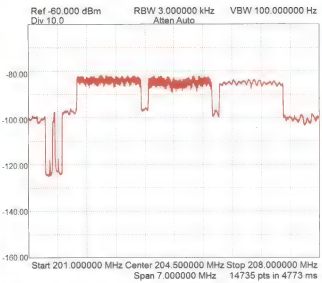


Fig.2: a spectrum plot showing the Sydney DRMT DAB+ signal block centred on 204.5MHz in channel 9A, captured using Spike 3.06 and saved as a JPEG file.

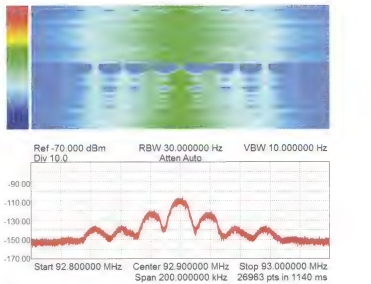


Fig.3: another plot centred on 92.9MHz, showing the Sydney ABCFM signal spectrum (bottom) with a 2D spectrogram above it. Spike again saved it as a JPEG file.

ware can be downloaded and installed at no charge, it will only work with Signal Hound devices like the USB-SA44B. When you start up the software it automatically searches the PC's USB ports to see if one or more of the devices is connected. When it finds one, it displays the device's serial number and other information (like internal temperature and firmware revision) at bottom right on its main display window; otherwise it refuses to proceed.

What's new?

The first thing you notice when you fire up Spike (in my case, with a USB-SA44B) is that the user interface window has been completely revamped. The main display graticule is now centred on the screen, with control panel menus running down either side. It's less crowded than before, having been proportioned to suit the 16x9 widescreen aspect ratio used on most modern laptops and PC monitors.

As before, the main functions, settings and facilities are selected using a menu bar and toolbar running along the top. The control panel menus on the left side then allow you to set the Measurement trace and marker parameters, any offsets that may be required and settings for Channel Power and Occupied Bandwidth measurements.

The menus on the right side control panel allow easy setting of all sweep parameters: Frequency (Centre, Span, Start, Stop and Step, plus the ability to set the analyser for either Full Span or Zero Span [more about this later]);

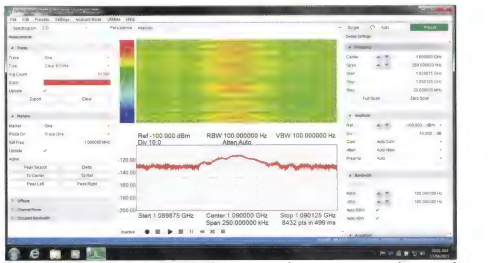


Fig.4: this full-screen grab shows Spike 3.06 in real-time scanning mode, centred at 1090MHz (the frequency used by commercial aircraft for ADSB). The 2-D spectrogram is shown above the spectrum plot itself.

Amplitude (Reference Level and Graticule Divisions, plus the ability to select either manual or automatic internal gain, attenuation and preamp enabling); Bandwidth (RBW and VBW); and finally Acquisition options such as Video units, Detector mode and Sweep Time.

This is not Spike's only display graticule or control menu panel, as will become clear shortly. So Spike's initial window is much snazzier than that of the original Signal Hound software. But that's only the start of its new features and capabilities, because the new software can now take full advantage of the capabilities of Signal Hound's analyser hardware – including those of the USB-SA44B.

For example, you can now select either of two different types of spectrogram to accompany the analyser's main amplitude vs frequency display: a 2D spectrogram which gives the moving "waterfall" display or a 3D spectrogram which gives a series of sweep displays receding into the distance. These can both be helpful when you're trying to look for significant events.

Another nice new feature applying to the main graticule display is persistence. When you enable this feature, the current signal trace is accompanied by a "community" of earlier traces, in colours representing their time prior to the current trace.

It's a bit like having a fixed spectrogram displayed directly behind the

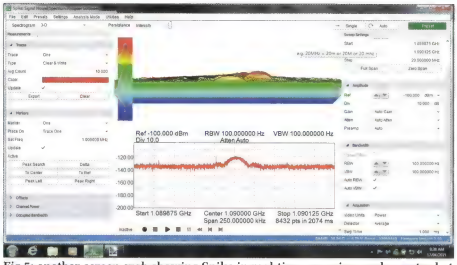


Fig.5: another screen grab showing Spike in real-time scanning mode, centred at 1090MHz, this time with a 3-D spectrogram shown above the spectrum plot.

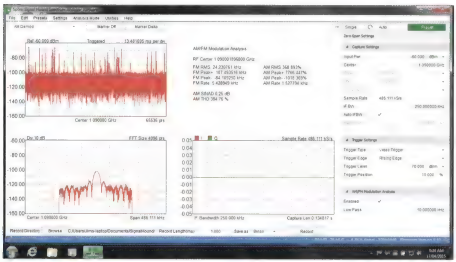


Fig.6: this screen grab shows Spike 3.06 in "zero span" mode – another of its exciting new features, designed to facilitate modulation analysis. It shows the actual spectrum plot at lower left, with the modulation plotted against time at upper left and the I/Q IF output stream at lower centre. A summary of the signal and modulation data is shown at upper centre.

trace itself, in the main graticule.

There's another new feature that's even more impressive: Spike now provides a real-time spectrum analysis mode, to allow capturing occasional short-term events which can easily be missed in normal sweep analysis if they occur during the "dead time" between sweeps.

In real-time analysis mode, Spike takes advantage of the ability of Spectrum Hound's analyser hardware to stream its full IF bandwidth back to the PC (via the USB cable) continuously, with no time gaps. So by limiting the sweep span to the maximum instantaneous bandwidth, Spike is now able to process and analyse every spectrum sample in real time.

Incidentally, the spectrogram and persistence features can be applied in real-time mode just as easily as in sweep mode. If this isn't enough, there's now a zero-span analysis mode too. This might sound a bit strange but it's really quite easy to understand. In zero span mode, Spike directs the analyser to stay locked to the centre frequency you've set, while it again streams the full IF bandwidth back to the PC.

This allows Spike to demodulate any AM, FM or PM modulation which may be present on a signal at that centre frequency. As a result, when Spike is in zero-span mode, the screen changes dramatically, with the RF amplitude vs frequency spectrum graticule reduced in size and moved to the lower left, while the modulation is displayed plotted against time in a new graticule across the top.

In addition, the I and Q components of the analyser's IF data stream are displayed in a third graticule at lower right, alongside the amplitude vs frequency plot. Then if you enable Spike's AM/FM modulation analysis feature, the upper modulation vs time graticule contracts to the left, and quite a bit of modulation analysis data is displayed in the top right quadrant.

You're shown a continuously updated summary of RMS, Peak+ and Peak- modulation percentages, plus the modulation frequency and RF centre frequency, together with the SINAD (dB) and THD (%) figures.

Other features

There are other noteworthy features as well, including:

(1) The ability to call up an Audio Player function, to listen to any AM or FM modulation of the centre frequency signal via the PC's speakers;

(2) The ability to call up a Measuring Receiver function, to display various key parameters of the centre frequency signal;

(3) The ability to record the data from an analyser session as a file on the PC, and also to replay a recorded file for further analysis;

(4) In zero-span mode, there's also the ability to save a short duration I/Q capture, either as a binary file or in a text-based format such as a CSV (comma separated variable) file;

(5) The ability to plot phase noise and

(6) If you add a USB-TG44A Tracking Generator to your set-up, the software can be easily set up to perform scalar network analysis.

In short, Signal Hound's new Spike 3.06 software really expands the measurement applications of their USB-based spectrum analysers (like the USB-SA44B) dramatically, as well as taking full advantage of the hitherto-hidden performance features of the analyser hardware.

The new User Manual for Spike is also a significant improvement on the original manual, which was already pretty good.

In Australia and New Zealand, Signal Hound products like the USB-SA44B and the USB-TG44A are distributed by Silvertone Electronics, now based in Wagga Wagga, NSW. You'll find their website: www.silvertone.com.au SC

Final part of our quality Weather Station based on ARDUINO

Pro2 wireless weather station WeatherDuino

System designed by Armindo Caneira*
Built and written by Trevor Robinson
*www.meteocercal.info

The Wireless Display Unit

In the last part, we built the RX unit and configured Cumulus to collect, record and display your weather data. Now we are going to complete the Weather Station by building the handy little Wireless Display unit (WDU).

The Wireless Display unit actually evolved from the RX unit (which, incidentally, can also be used as a WDU with some minor mods).

It receives wireless data on a 433MHz link from the RX unit (see part 3), which in turn has received data from the outside weather sensors via the TX unit (see part 2).

It also sends data from its own DHT22 temperature and humidity sensor. The main differences between the two is the barometer sensor and the run/program pullup switching has been omitted.

And of course, it has its own firmware file.

Beside having a display screen, it only has one push-button switch (the Display Mode switch) and a LED. The LED blinks when data is received over the 433MHz link.

The WDU is powered through its Mini-B USB connector, so you will need a 5V DC power pack with a mini-B USB connetor or a Mini-B USB cable to connect it to a suitable power supply like a USB phone charger.

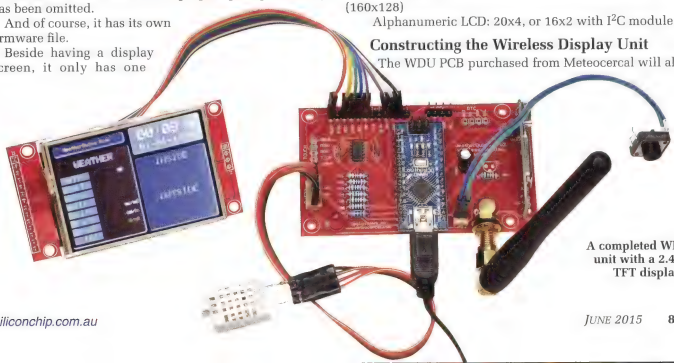
Once again, like the RX unit, you have the option of one of the following five different displays:

TFT – ILI9341 2.4" or 2.2" (320x240) or the ST7735 1.8" (160x128)

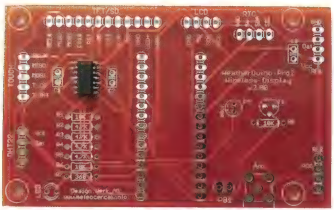
Alphanumeric LCD: 20x4, or 16x2 with I²C module

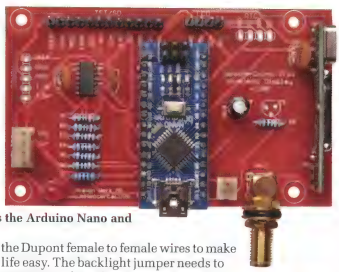
Constructing the Wireless Display Unit

The WDU PCB purchased from Meteocercal will al-



A completed WD unit with a 2.4" TFT display





(Above): reverse side of the WD PCB; the "top" side at right has the Arduino Nano and 433MHz modules fitted.

ready have the surface mount components soldered on, as shown above (there is also an SMD on the opposite side). These can be a bit tricky without the correct tools.

Once again, like all electronic kitset projects, it's easiest to install and solder in the smallest components first: the resistors and capacitors.

Next install the LED, observing the polarity, followed by the header and antenna connectors.

Like last month, it's best to install the Nano using a suitable socket. But if you are soldering the Nano directly to the PCB, it's good practice (as with all heat sensitive components) to stagger the soldering of the pins to help avoid localisation of heat build up.

Finally install the BX-RM06 ASK OOK RF receiver module vertically on the WDU board. Ensure that the component side of this board goes to the outside of the WDU board pin – its easy to install this component back-to-front if care isn't taken. Not only will it not work, it will quite likely be damaged (and it's a pain to desolder!).

The WDU board is now complete but before moving on, double check your work, looking for solder bridges (especially between module and header pins) and cold solder joints. A jeweller's loupe or magnifying lamp are great tools for getting a good close-up view.

Connecting the display screen

Much of the following information is repeated from last month's (Part 3 – The Receiver) issue because the Wireless Display Unit and Receiver Unit share a common heritage and indeed, most parts are interchangeable.

TFT display

Use nine of the Dupont female to female wires to connect PCB pin headers to TFT pin headers.

Currently the SD card and touch overlay are unused.

Alphanumeric LCD

The LCD connection process is simpler as it only uses four wires. You can also use four of the Dupont female to female wires to make life easy. The backlight jumper needs to remain in place, but you may need to tweak the contrast potentiometer.

TFT pin assignment

PCB	TFT Display	2.4" TFT – ILI9341 320x240
SCLK	SCLK	SCK
MOSI	SDA	SDI(MOSI)
CS	CS	CS
RST	RESET	RESET
DC	A0	D/C
5V	VCC	VCC
GND	GND	GND
LED+	LED+	LED
LED-	LED-	No connection needed

LCD Pinouts

PCB	LCD
GND	GND
5V	5V
SDA	SDA
SCL	SCL

Connecting the DHT22 temperature sensor

This is the same as what we did for the RX unit. We'll cover it briefly again, just in case your dog ate your ~~homework~~ last article.

Solder four header contact pins to one end of whatever length of cable you require. The maximum length this cable can be is five metres. Solder and heatshrink the other end to the four legs of the DHT22 sensor.

DHT22 Temp. Sensor

PCB	Schematic Pin	DHT 22 pins
GND	1 (GND)	3 OR 4
DAT	2 (D6)	2
5V	3 (5V)	1

Ensure the pin assignment matches the table above.

Push button (display mode switch) and LED (data received indicator)

Both of these are dependent on what sort of case you get.

The momentary action pushbutton switch should be connected by soldering wire to the contacts and then the other end to the contacts of the header connector plug. The LED can be soldered into its position on the PCB, though it would be better to use a suitable length of cable to connect it to the PCB from somewhere visible on the case. The push button changes the display mode as per the table below:

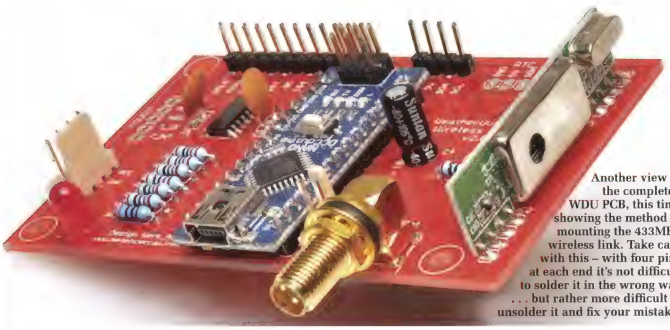
Display Mode Switching

Button Action	LCD	TFT
Short press	Nothing	Toggles the Display off/on
Long press	Nothing	Toggles the big font size screen
Double press	Toggles the information screen	

The information screen shows the firmware version, TX unit voltage and case temp from the TMP36 sensor.

Programming the WeatherDuino Pro2 Nano

Since you are now an old hand at programming Arduinos, we shouldn't have to go into too much detail here. If you



Another view of the completed WDU PCB, this time showing the method of mounting the 433MHz wireless link. Take care with this – with four pins at each end it's not difficult to solder it in the wrong way . . . but rather more difficult to unsolder it and fix your mistake!

need a refresher, part two had an in-depth guide to setting up the IDE and part three covered reading and altering of the WeatherDuino code to suit that application; maybe read those again.

Acquire the required firmware

Download the required firmware file from here: www.meteocercal.info/forum/Thread-WeatherDuino-Pro2-WD-Software-Latest-Release

Save the file to wherever, then extract the contents into your Arduino sketch folder which should be in the \users\your_username\Documents\Arduino folder. Click "OK" on any merge or overwrite dialog boxes.

Now go into that folder and double click the folder WeatherDuino_WD_vxxx_bxxx (the "x"s change by release version). Then in that folder there should be a file called WeatherDuino_WD_vxxx_bxxx.ino – double click that to open it in the Arduino IDE.

Configuring the code

Now we need to tweak a few lines to suit our WDU setup. Scroll down to around line 44.

We need to start by changing the code to suit our display type, so pick your display type number from the comment section: 0= TFT 160x128 ST7735, 1= TFT 320x240 ILI9341, 4= 20x4 LCD, 5= 16x2 LCD

Say your have the big LCD display, you would change the line to read this:

```
#define DisplayType 4    // 0= TFT 160x128 ST7735, 1= TFT 320x240 ILI9341, 4= 20x4 LCD, 5= 16x2 LCD
```

The big TFT display is set to the default so you would just leave that line as is.

Next is the Backlight timeout:

```
byte BackLight_Timeout =  0;  // Timeout for TFT backlight in minutes (1 to 255). 0= Always ON
```

You have the option of having it on continuously (though a short button press turns it off) or setting the timer to turn it off automatically some time after the last button press. Your choice. If you want to just manually turn off the backlight then just leave the default setting.

Next is the Temperature sensor type. Since we when with the good old DHT22 you can left this line alone also.

The next line you also leave at the default setting of 1

```
#define Board_Type 1    // 0= Standard Boards, 1= Extended version Wireless Display Boards
```

Pretty simple configuration on this unit isn't it?

Save it with a filename that reflects your setup so if you wish to tweak/change it in the future, you will know what it is.

Compile and upload it to the Nano by pressing the right arrow in the Arduino IDE. After a short period of time the WeatherDuino Pro2 Wireless Display unit should reboot and a little while later the inside temperature should be displayed and after a little more time the outside data should display.

If the IDE produces errors its usually one of two things:

1: File too big. Your are not running the Arduino IDE version 1.5.8 or greater.

2: The library files are not where the IDE is expecting them. Double check they are in the sketch folder or manually import them in the IDE (Sketch/Import Library).

That's all folks!

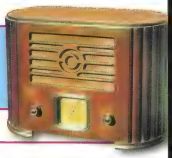
We hope you enjoyed creating this project and find the data this weather station creates is more reliable and accurate than your previous station may have produced, or even the weatherman on the radio.

We certainly did!

When you get you weather station online, please leave a post on the Meteocercal forum so you can have your station added to the WeatherDuino user map here: www.meteocercal.info/forum/misc.php?page=WeatherDuino_Users_Map

SC

Vintage Radio



By Ian Batty

The Philips model 198 transistor radio

Philips' first Australian-made transistor set

Housed in an attractive leatherette case, the model 198 was Philips' first Australian-made transistor set. It was a 7-transistor design and both it and the later model 199 offered excellent performance.

BEGINNING IN Eindhoven in 1891 and founded by Gerard Philips and his father Frederik, Philips became one of the world's largest technology companies but today it concentrates on lighting and healthcare. The company began manufacturing in Australia in 1931 but produced only two models before temporarily halting production and then resuming in 1934.

Philips then quickly grew to become one of Australia's largest electronics manufacturers, with radios sold under the Briton, Mullard and Fleetwood brand names. TV receiver production subsequently started in 1956 and continued until the 1980s. In addition, Philips manufactured valves, TV picture tubes and transistors, including the famous OC44/45 and OC70/71/72/74 series that many of us bought to build our first transistor sets.

Design highlights

Described in Vintage Radio for April 2015, Australia's first transistor radio, the AWA 897P, was released in 1957. This was followed just a year later by Philips with their model 198. Like the 897P, this was another 7-transistor design and the case used by Philips was modelled on a previous valve version, the compact AC/battery model 196.

AWA's engineers used three audio stages in the 897P, based on four transistors and three transformers. By contrast, Philips opted for a design that was to become standard, with just three transistors and two transformers used for the audio amplifier. Like AWA, Philips paid attention to Australian conditions, by employing a thermistor-stabilised output stage. They also added adjustable output stage bias, as described below.

The Philips 198 was more compact than the AWA 897P and it looks somewhat like a small cosmetics case. But don't let its "domestic" appearance fool you – it really is a very good radio. The accompanying photos show the set's controls which are, from left to right: Volume, Off, Treble/On and Bass/On along the top and, on the front panel, a tuning control with integral dial.

Philips 198 chassis details

Like Bush's TR82C and AWA's 897P, the Philips 198 uses a pressed-and-punched metal chassis. Its successor (the 199) is similar but with sufficient differences to warrant a separate circuit diagram (the major differences are noted in the text).

The 198 has five of its transistors installed in chassis-mounted rubber grommets, with the leads wired to adjacent solder tags. By contrast, the two output transistors are held in heatsink clips which are screw-mounted on the underside of the chassis.

Unlike the AWA set, the chassis sits horizontally inside the case, allowing some access to the underside where most of the components are mounted on tagstrips. The IF transformers and the LO coil, however, are mounted ver-

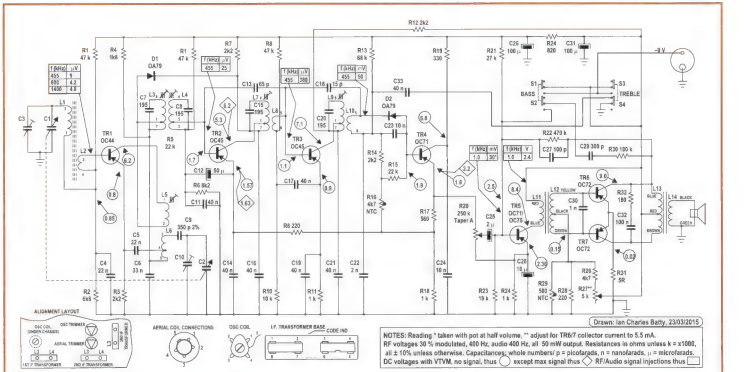


Fig.1: the circuit details of the Philips 198. TR1 is the converter stage, while TR2 & TR3 are the IF amplifier stages. D2 is the detector and this feeds buffer stage TR4 which in turn drives an audio amplifier based on TR5-TR7.

tically, so that the chassis still needs to be removed for any detailed work, including alignment.

The case itself is made from leatherette-covered "composite" material (cardboard), while the front dial at top-right turns easily with a direct drive. To the left of the dial is a large speaker grille. Power is controlled by pushbutton switches, so the volume pot only controls the volume. Because it doesn't also function as an on/off switch, the volume pot doesn't have to be turned down to or up from zero each time the set is turned off or on, thereby extending the pot's life.

Circuit details

Fig.1 shows the circuit details of the Philips 198. Transistor TR1 is the converter stage and this operates as an autodyne oscillator with collector-emitter feedback. AGC is not applied to this stage, so TR1 operates with fixed bias.

As shown, TR1's bottom divider resistor (R2) and its bypass (C4) are connected between the "cold" (bottom) end of the ferrite rod's two windings (tuned and base) and ground. This means that the bottom of the antenna windings are at base bias voltage, thereby providing a handy test point. By contrast, the later 199 model connects both antenna windings directly to ground, with the bottom of the base bias circuit going to the top of the base winding.

The base-emitter voltage is only 50mV, since converters must operate close to Class B conditions to give the non-linear "modulating" effect needed for frequency conversion.

Because the tuning gang uses identical sections, padder capacitor C9 is included to modify the capacitance range of the oscillator section so that the local oscillator tunes from about 990-2060kHz. The only unusual feature is that the oscillator coil's secondary is held at the converter's collector voltage. While this eliminates any potential difference between primary and secondary, it's not common practice.

Converter TR1 feeds the first IF stage (TR2) via IF transformer L3/L4 which has tuned and tapped primary and secondary windings. TR2 is gain-controlled by the AGC system and due to the high feedback capacitance of alloyed-junction transistors, this stage is neutralised by feedback via C13 from the second IF transformer's untuned (and untapped) secondary. By contrast, in the 199 model, this feedback is derived from an overwind on the second IF transformer's primary. In addition, the second IF transformer has a tuned and tapped secondary.

The second IF stage is based on TR3 and runs with fixed bias. It's also neutralised, via C19, and both the 198 and 199 models derive feedback from the third IF transformer's secondary.

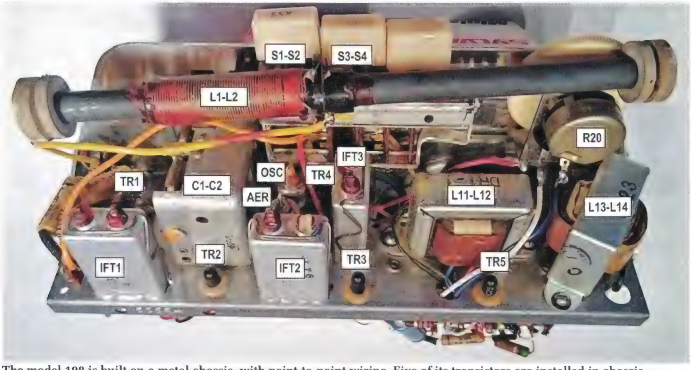
The third IF transformer uses a tuned, tapped primary and a low-impedance, untuned secondary to feed demodulator diode D2.

AGC circuit

Depending on the strength of the incoming RF (and IF) signal, diode D2 provides a negative DC output to the base of TR4, the first audio/AGC stage transistor which is connected as an emitter follower to buffer the detector.

Stronger IF signals will therefore cause TR4's emitter current to increase but it does not amplify the resultant audio, merely passing it to the following volume control potentiometer (R20).

However, the DC signal from TR4's emitter is then filtered by capacitor C14, so that the resultant DC voltage is more or less proportional to the IF signal strength. This DC voltage is applied to the emitter of TR2 and if this voltage increases, TR2's gain will tend to be reduced. As a result, changes in signal strength are counteracted and the set's output remains substantially constant for varying signal strengths.



The model 198 is built on a metal chassis, with point-to-point wiring. Five of its transistors are installed in chassis-mounted rubber grommets while the two output transistors are held in heatsink clips which are screw-mounted on the underside.

As well as AGC, the set also includes an "overload diode", better described as an "AGC extender". Simply controlling one stage (such as TR2) only provides a limited range of control. In this set, the stage gain is some 30dB and thus simple AGC can only counteract about this range of input signal. After that, the audio output begins to rise noticeably or the second IF stage goes into overload.

To prevent this, auxiliary AGC diode D1 is connected between the primary of the first IF transformer (L3) and the collector supply to TR2 at the junction of R7 and C16. This latter junction sits at about -5.4V DC but is effectively at signal ground due to C15. By contrast, D1's anode at L3's primary sits at about -6.2V DC and is at IF signal level. It's also connected (via L5) to converter TR1's collector.

With no signal, D1 has around 0.8V of reverse bias. As TR2's collector current falls with increasing signal, its collector voltage (developed across R7) rises. This pulls D1's cathode towards the supply voltage and (importantly) reduces its reverse bias. As TR2's collector current falls further with increasing signal strength, D1 eventually begins to conduct and damps the IF signal at TR1's collector, thereby preventing it from increasing.

The result is that the model 198 has effective AGC and provides consistent audio output levels over a wide range of signal strengths.

Audio stages

The audio stages begin unconventionally with the emitter follower/buffer stage based on TR4. It's more usual to see a common-emitter stage here but given the AGC design (which feeds some current through NTC thermistor R16 in order to operate), it makes sense. In operation, TR4's bias is temperature-stabilised by R16, presumably to prevent TR4's AGC action from being disturbed by high or low ambient temperatures.

Following TR4, the signal is fed to the remaining audio stages via volume control pot R20. Its circuit configuration is also unconventional: its "hot" end connects to TR4's emitter and its "cold" end goes to TR5's emitter, which produces about 0.7V DC across the pot. However, because TR5's emitter is at AC (signal) ground, R20 works just fine as a volume control. The peculiarity is that there is standing DC across the pot, which is usually a recipe for noisy operation.

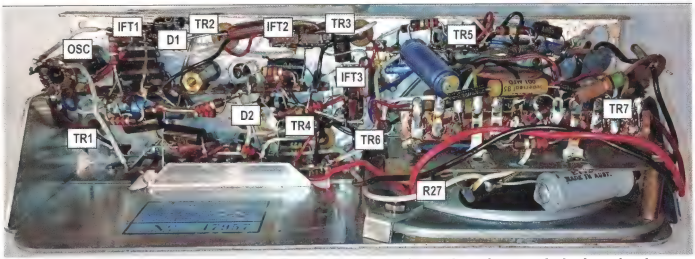
Audio driver TR5 is a conventional transformer-coupled stage. No treble roll-off is applied here but was added in the 199 model. It is, however, applied in the output stage using R32-C32, with the 100nF capacitor increased in value for the 199.

Push-pull output stage

The push-pull Class B output stage is based on TR6 & TR7 and has thermistor-compensated bias (R29). This bias can be adjusted using R27. The model 198 also has a shared 5Ω emitter resistor (R31) but this was removed for the 199. At 5.5mA, the bias current is a little higher than in most other sets but I found that I was able to set it to almost zero with no noticeable increase in crossover distortion. The alignment guide, by the way, recommends running the set for three minutes prior to checking or adjusting the output stage bias.

In the model 198, audio stage feedback is applied from TR6's collector to TR5's base via two paths. First, there is a permanent feedback path via R22-C27 (the 199 uses a single 220kΩ feedback resistor and takes the feedback from the speaker terminal). And second, Bass switch S1/S2 switches C29 and R30 across the feedback path to apply extra treble roll-off (the 199 uses slightly different values here). In operation, this brings the upper -3dB point down to just 2kHz (the model 199 also derives this "top-cut" feedback from TR6's collector).

S3/S4 (Treble) switches in C33 to



This is the under-chassis view of the model 198. The set was still in working order and no parts had to be replaced, although the set did require alignment adjustments in order to optimise its performance.

provide extra bypassing for the demodulator (this is absent on the 199). Like the Bass switch, it also turns the set on via its second set of contacts.

By the way, the circuit shown here is a redrawn version, since the original circuit isn't all that clear (at least as found online). The original component numbering has been preserved.

Restoration

The set shown here was quite tatty when I took it out of storage. On the outside, its leatherette-covered composite case and tuning dial were dirty and the metalwork was tarnished and corroded. In addition, the Philips badge on top (just behind the switch well) and the "All Transistor" badge inside the escutcheon were both bent. It's a common problem and of the four 198/199 sets I have, this one was the best preserved.

I attacked the leatherette case first using a microfibre pad but soon noticed that some of the fawn colour was transferring to the pad. I'd also had a similar experience of colour lifting with the Bush TR82C, so I'll use these microfibre pads with caution in future.

In the end, the case was cleaned using spray cleaner, a toothbrush and good old-fashioned elbow grease. I then repeated the exercise on the tuning and volume control knobs. The lettering on the switches was almost absent but I decided to leave restoring them for another time.

The metal strap covers, the switchbank end pieces and the Philips badge all cleaned up nicely with Brasso but the escutcheon trim was more problematic. Rather than polish it out of existence, I left it with the minimum of treatment.

Unfortunately, the strap stitching had all but disappeared but that's also a job for another time. On the other hand, the electronic circuitry all looked good, with no battery corrosion or other visible issues.

How good is it?

So just how well does the Philips 198 transistor radio perform? The answer is "surprisingly well".

First, the selectivity is quite narrow, being just ± 2kHz at the -3 dB point and ±20kHz for 60dB down. It's wider than the AWA 897P's with its six tuned IF circuits, however.

The RF performance was so good it had me rechecking my results. During alignment, I discovered that the oscillator coil slug was jammed tight. Another set had the same problem but after some fiddling about with various other adjustments, I managed to obtain 50mW output for a signal strength of just 40µV/m at 600kHz and 42µV/m at 1400kHz (although with only 16dB and 15dB S/N ratios respectively).

In the absence of oscillator adjustment, the classic solution is to adjust the antenna circuit by sliding the tun-

Philips 199 Transistor Radio – Differences

The 199 and 199AC look very similar to the model 198 but incorporate several component and configuration changes, as follows:

(1) Bypass capacitors C11 & C14 changed from 40nF to 10nF;

(2) Neutralising capacitor C13 changed from 65pF to 50pF and connected to an overwind on IFT2's primary rather than to its secondary;

(3) Neutralising capacitor C18 (15pF) becomes C19 (10pF);

(4) Audio input coupling capacitor C25 (2µF) becomes C26 (10µF);

(5) Treble-cut capacitor C25 (10nF) added between TR5's collector and ground (model 199 only);

(6) Treble-cut capacitor C32 changed from 100nF to 220nF;

(7) Feedback capacitor C29 (Bass position) changed from 300pF to 200pF;

(8) Feedback resistor R22 reduced from 470kΩ to 220kΩ and its parallel capacitor C27 deleted;

(9) Feedback resistor R30 increased from 100kΩ to 220kΩ and resistor R31 replaced with a link.

(10) As noted in the article, the 199 sets alter the connection from the ferrite rod to the base of converter stage TR1.

(11) The 198 derives all of its audio feedback from TR6's collector. In the model 199, it's permanently derived from the speaker, while Bass position feedback is still derived from TR6's collector and the Treble switch feedback has been omitted.

All controls except for the tuning control are mounted on the top of the case. These include the volume control at left plus pushbutton switches for power off, treble/power-on and bass/power-on. The lettering has mostly worn off the pushbutton switches.

ing coil along the ferrite rod. Sliding it towards the centre gives increased inductance, while moving it towards the end reduces the inductance. However, this adjustment on my set didn't offer much improvement.

I then decided on more drastic measures in the form of a hot-air gun applied to the oscillator coil, the intent being to soften the wax covering sufficiently to loosen the slug. It did no good; the slug still wouldn't move. In the end, rather than damage the slug by over-zealous pressure, I left the set with the best alignment possible.

In order to obtain the standard 20dB S/N ratio, the signal strength needed to be about 60μV/m at 600kHz and 65μV/m at 1400kHz. Compared to the AWA 897 and to the even better-performing Bush TR82C, this little Philips set is an absolute gem. It's nearly as good as the most sensitive set I've tested so far, the outstanding Pye Jetliner.

It's also interesting to compare it to its model 196 valve predecessor. On test, my 196 required a radiated signal of just 25μV/m at 1400kHz for a 50mW output and just 6μV at the aerial terminal for the same output.

The Philips 198's AGC control is excellent, with the output rising by just 16dB for an input signal increase of some 66dB. It does go into overload after some 40mV is fed directly into the converter's base. This is equivalent to a field strength of about 500mV/metre, so "overload" for this set means "sitting right under the tower".

Audio performance

Like most small sets, the audio performance is adequate without being outstanding. Its frequency response from volume control to loudspeaker with S3/S4 in the "Treble" position is around 100Hz to 3.9kHz, with a 3dB peak at 250Hz. Switching S1/S2 to "Bass" position cuts the top end response to around 2kHz.

By contrast, the overall response when measured from the antenna terminal to the loudspeaker is only about 150Hz to 1kHz (S3/S4 in the "Treble" position).

The audio stage goes into clipping at about 160mW output, at which point the total harmonic distortion (THD) is around 6%. This increases to about 10% THD at 180mW. At 50mW, it's a bit under 1% and it maintains this figure for an output of just 10mW. This indicates that crossover distortion is well-controlled.

If the battery voltage drops to 4.5V, it clips at around 45mW. However, even at this low supply voltage, the crossover distortion is only just noticeable at 35mW output.

Would I buy another?

So would I buy another model 198 or 199? Well, I did actually. It's the look-alike 199C which is fitted with alloy-diffused OC170/169s in the RF/IF end and OC74s in the output stage.

If you can get either the 198, the 199 or the 199C, you'll have a fine little set that may appear unremarkable compared to other designs. But once you start using it, you'll be reminded of just how good it is. We'll find out just how good the 199C is in a forthcoming article.

Further reading

(1) For the 198 and the 199 circuits, see Ian Malcolm's Transistor Radio Page: http://transistor.bigpondhosting.com/circuits/philips198.jpg

(2) For information on the 199AC, including service data, see Kevin Chant's website: http://www.kevinchant.com/uploads/7/1/0/8/7108231/199ac.pdf SC

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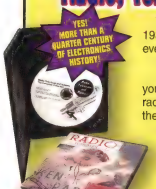

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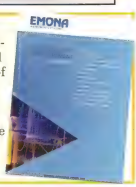

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High-voltage probe for multimeters

I was just wondering if Silicon Chip has ever presented a 6000V or 10,000V probe adaptor for multimeters (I saw the High-Voltage Probe for Oscilloscopes in the January 2015 issue).

Commercial high-voltage probes are available for multimeters but they cost many times more than the cost of a multimeter. It could be a useful project, if it hasn't been done already. (B. P., via email).

● Have a look at the EHT Stick, a 1000:1 high voltage probe for multimeters, in the April 2010 issue. It is rated for use up to 35kV. You can see a free 2-page preview of the article at www.siliconchip.com.au/Issue/2010/April/A+1000%3A1+EHT+Probe

An Altronics kit for this design (Cat. K2559) is available.

Battery charge controller for drill packs

I recently purchased a reasonably good battery drill from Bunnings with their Ozito brand. As usual, the charger is not up to scratch. I think it only lights a couple of LEDs, one to show power is on and the other when the battery is connected.

I remember seeing a couple of projects in Silicon Chip regarding drill chargers. The battery packs (it came with two) have 12 1.2V 1200mAh Nicad batteries, giving a total of 14.4V. Can you point me in the right direction as to which project I need? (M. F., via email).

● Have a look at our Cordless Power Tool Charger Controller in the December 2006 issue. You can see a free 2-page intro to the article at www.siliconchip.com.au/Issue/2006/December/Cordless+Power+Tool+Charger+Controller

Loudspeaker protector for SC480 amplifier

I am putting together a pair of SC480 amplifier modules (Silicon Chip, January & February 2003) and I want to add a Loudspeaker Protector, mainly to avoid switch-on thumps. I was advised by the staff at my local electronics supplier to purchase the Loudspeaker Protector for the CLASSiC-D amplifier (Silicon Chip, November & December 2012), on the basis that it can cope with a range of amplifier supply voltages. Is it suitable or do you have another design that I should use?

Also, I want to connect a headphone socket to the two amplifier modules. Can I just use a pair of 390Ω 1W resistors to do this? (J. M., via email).

● You have been given a classic "bum steer". The CLASSiC-D protector is only suitable for the CLASSiC-D amplifier, as it has a pair of optocouplers to monitor the "protect LED" in each channel of the amplifier module. It will not work with any other amplifier module.

You need one of our general-purpose loudspeaker protectors and we would nominate the design featured in the October 2011 issue. It is still available as kit from Altronics (Cat. K5167) or you can purchase the PCB from our Online Shop. Mind you, a Loudspeaker Protector is not strictly necessary with the SC480 amplifier modules since they already incorporate short-circuit and over-current protection in the form of a PTC (positive temperature coefficient) thermistor in series with their outputs. This goes high in resistance when an overload condition occurs and reverts to a low resistance if the fault condition is removed.

However, the PTC thermistors will

DMM Confused By DC With Superimposed 100Hz Ripple

I have a fully assembled Currawong valve amplifier that's failing its preliminary checks – specifically excessive levels of AC on all the DC supplies. I've spent many days troubleshooting this and tried everything I can think of, including double-checking every component and joint.

As per the instructions, the valves have not been inserted yet. I've applied power and the blue LEDs light immediately. After 20 seconds or so the power LED changes from red to green. All good. I've attached a power supply schematic with DMM measurements shown.

The only things I can add that might help are that if I take the same measurements with my old moving coil meter, the DC voltages are pretty much the same but all the AC voltages are about half those indicated by the DMM. I'd guess that the AC I'm measuring isn't 50Hz. The power LED cycles and I have lower DC and AC voltages even when the fuses have been removed!

I did do a lot of testing with CON7 disconnected because I didn't want to have to worry about the lethal voltages all the time. I still had the same AC and DC voltages at CON9 and on the 12V DC supply. There were still small AC and DC voltages on the HT supplies.

If there's anything you can suggest I'd really appreciate it; a lot of investment in terms of time and money here. Please don't publish this if I've done something really stupid! (D. H., via email).

● We think everything in your amplifier is probably OK and that your multimeter is confused. If you are going to check for AC on a DC line, you need to measure it via a high voltage blocking capacitor. Try using 100nF 400V.

Editor's note: this diagnosis subsequently proved to be correct.

Problem With The CLASSiC DAC

Recently I built your CLASSiC DAC project from a series of articles in 2013 and I found that it had excellent sound and performance and is very versatile and useful with a wide variety of digital music sources. I have been a keen builder of all of your major hifi projects. However, after successfully operating the project for about a month, it refuses to start up normally.

During normal operation, I noticed that there were occasions where the unit would lock up (would not play music but I could select inputs) but I was always able to successfully reset the unit by reconnecting the 9VAC plugpack supply. I now find that the DAC has locked up completely, is no longer responsive to the remote control inputs and no longer plays music. The only sign of life is the flashing of LED number 6 on the front panel.

I have checked the power supply voltages and they are all on spec. When the DAC is first connected to the plugpack, all the input LEDs flash very briefly then the yellow sampling LEDs light in sequence from right to left before extinguishing. Finally, after a delay of several seconds, the SPDIF input LED (input 6) flashes regularly. It cannot be turned on by the remote or front switch. I have tried changing the four switch settings but the symptoms are the same. Also, if the SD card is inserted, it is not detected, as indicated by LED8 and LED6 goes into a periodic flashing mode.

Presumably the CPU is executing a self-check routine and it has found something amiss with the hardware, I/O states, clock or software. I am not sure where to fault-find with these symptoms. What checks should I conduct with hardware and is it possible to check the CPU file using the ICSP connection and verify the checksum? I purchased the HEX file along with the hardware from your Online Shop but I cannot find any way to download it to reflash the CPU.

Having sampled how well this project sounds I am really keen to get it going again. (J. C., Armadale, Vic).

● There appear to be two different things going on here. Switching an associated power amplifier on or off can "upset" the CLASSiC DAC and the DAC requires a reboot to operate properly. We think what's happening is that there is a large mains/EMI spike when the amplifier's supply current is interrupted and this is coupling into the CLASSiC DAC and possibly resetting the DAC chip.

The microcontroller is still trying to communicate with it but since the DAC has been reset and its settings have been lost, it doesn't work properly. When this happens, sometimes you still get audio but it sounds distorted, as if the bit-stream format setting in the DAC is no longer correct.

Adding shielding to the plastic case could help, especially around the CS8416 IC. Modifying the software to periodically check if the DAC's settings have been "lost" or corrupted and re-initialising it if so could also help. It's strange because the Reset line is actively held during normal operation but perhaps the EMI spike is big enough to couple directly into the IC.

Unfortunately, we haven't yet had the time to fully investigate this.

You are right that the S/PDIF input LED flashing is a sign that one of the self-test routines has failed. At power-up the unit checks that it can communicate with the PLL1708, then the CS8416, then the CS4398. LED6 flashing probably indicates a failure to communicate with the CS4398.

We suggest that you carefully inspect its soldering. It's possible that one of the leads is not properly soldered and it was making sufficient contact to operate earlier but due to thermal expansion or a bump or something else, it no longer is. You might as well check the other SMDs at the same time but we'd concentrate on the CS4398.

Re-flowing its leads may fix the problem. If not, it's possible the IC has failed, although that seems pretty unlikely. Check the micro also since a soldering problem on its pins may also have this effect.

Editor's note: reflowing the IC pins subsequently fixed the problem.

not offer any muting of switch-on and switch-off thumps. If it occurs, any switch-on thump is likely to be due to a preamplifier you might connect in front of the SC480 module, so if you won't be using a preamplifier, there should not be any switch-on thump and any switch-off thumps should be very slight.

If you do decide to use the Loudspeaker Protector with the SC480 modules, you could consider omitting their PTC thermistors and just wire shorting links in their place. That way, you will get slightly lower distortion and slightly better damping factor for your loudspeakers although the improvement will be largely academic.

And yes, your method for connecting the headphone socket will be fine.

Converting watts to lumens

On the question of different types of lights and relative outputs, what is the formula to convert Watts to Lumens? For example, what is the Lumen output for a 12V 100W spotlight. (W. S., via Facebook).

● It all depends on the efficiency of the particular light. So what type of spotlight are we talking about? Standard incandescent, Xenon, halogen, white LED or HID (high intensity discharge)? That list ranges from the least efficient to the most efficient; more or less. Just to confuse the issue, spotlights also tend to be rated in candle power and it is really not possible to compare these parameters since candlepower is a measure of the most intense part of the beam and that, in turn, depends on the focus of the lamp and any lens or reflector.

Ultimately, you have to look at the lumen rating of the particular lamp you are considering. In general, as far as automotive spotlights are concerned, HID lamps and the latest high brightness white LED lights are far more efficient than the older halogen types.

Question about LED clusters

I am interested in using ultra-bright LED clusters of the type used in the Oatley Electronics Solar Skylight kit but I can't find any basic information

Regulators For Low-Frequency Distortion Analyser

I noticed that the circuit for the Low Frequency Distortion Analyser in the April 2015 issue has a +5V rail which isn't used. The accompanying text explains why two regulators are used but is there any reason why they can't be replaced with an LP2950CZ-3.3 regulator? This particular device has a wider input range (2.3-30V) and its use would also save on a couple of capacitors.

Talking about regulators, are there any hard and fast rules when it comes to choosing the values of the filter/smoothing capacitors on either side of a regulator? Some circuits I've seen would suggest the larger the better but data sheets show relatively small values. (T. B., via email).

● You could use a regulator which will tolerate a higher input voltage and get rid of the 78L05 but note that this means that all the dissipation will be in the one regulator. Given the relatively low current drawn by this circuit, that probably isn't an issue, even for a small TO-92 device.

Part of the reason we did it this way is that most small 3.3V regulators are not designed to handle an input voltage above 6V; obviously some do, including the LP2950CZ-3.3 that you mention. The other reason is that the 5V rail is used for other purposes when the PCB is built for the alternative function presented in this issue (ie, the Infrasonic Snooper).

You really need to check the data sheet for a particular regulator to determine capacitor values and types. Some regulators (primarily low-dropout types) are fussy about capacitor value and ESR. Sometimes they provide a graph showing the combinations of capacitance and ESR which will provide stability over some operating current range. In most cases, higher capacitance is not a problem but it isn't unheard of for too large a capacitance to cause loop stability problems and possibly also start-up problems due to the high initial charging current.

For the input capacitor, usually ESR is more important than capacity because instability due to poor input bypassing usually occurs at high frequencies. Something like a 1µF ceramic is fine for most regulators, especially if there is bulk capacitance upstream.

Higher values for the output filter capacitor usually improve transient response but there are diminishing returns; 100µF is usually much better than 10µF but 1000µF may not be much better than 100µF.

Paralleling a high-value capacitor with a low-ESR 1µF ceramic can be a good idea to better handle fast transients.

(eg,power calculation). Is there an idiot's guide? (T. U., via email).

● We presume you mean the LED clusters used in the Oatley Electronics K328 Solar Skylight kit (SILICON CHIP, January 2013). These use 20W LED clusters (20W, 34V, 0.7A) each comprising two parallel strings, with each string containing 10 series-connected 1W LEDs on a metal substrate. At 20W, each string draws 350mA and has 34V across it. So the typical 1W LED in the 10-LED string has about a 3.4V drop across it when driven at 350mA. This is just over 1W (1.19W) each.

Overall power delivered to the LED cluster is about 23.8W, assuming a 34V voltage drop and and 700mA current flow.

The cluster will need to have a heatsink to dissipate the power delivered to the LEDs as there will be considerable heat developed when powered at 20W. While LEDs are more efficient in producing light compared to incandescent lamps, they are still inefficient, overall. So expect that you would need to dissipate at least 18W of heat when driving the LED cluster at 20W. Ideally, the LED cluster should be driven at a lower current than 700mA since LED power should be de-rated as the temperature rises.

As far as specifications are concerned, you could check various manufacturer's data on 1W LEDs to see what they recommend with regard to running at full power and the de-rating with temperature.

For some information on driving 1W LEDs see www.youtube.com/watch?v=piET0Biqo0I

Missing functions in burp charger

I have recently built the Burp Charger (SILICON CHIP, March 2014) from a Jaycar kit and everything works except for the trickle charge and top-up functions.

After checking the board for faults I presumed the problem was in the programmed micro (IC1). I then purchased another programmed chip from Jaycar, with the same result. Reading from the write-up suggests that these functions can be added later, if required. Does this mean that they are not programmed on the IC1 purchased from Jaycar or in the original kit? If this is so, how do I get them programmed? (J. S., via email).

● Trickle and Top-up modes for the Burp Charger are set using DIP switches S2, as shown in the panel in the lower left corner of the circuit diagram on page 69 of the original article. Switch #2 on to enable Top-up and switch #3 on to enable Trickle Charging (see also the last section of the article). Follow the instructions to set the corresponding charge rates using trimpot VR3.

Different LCD for Spark Energy Meter

I would like to use a different LCD module from that specified for the Spark Energy Meter (SILICON CHIP, February & March 2015). Instead, I want use one sold by Dick Smith Electronics (Q2220) and Oatley Electronics for many years.

I will be building at least two of the Spark Energy Meters and I have several of the DSE LCD modules. Both modules are differential with 200mV sensitivity, have an input loading of 10MΩ and provide access to the decimal points.

I can find very little information on the Jaycar module. I cannot work out how Dr Hugo Holden has made the Jaycar module have a common signal and power supply earth and still work, so I am struggling to make the conversion (the DSE version shows how this can be done). (G. L., via email).

● One approach to drive the Dick Smith Q2220 LCD module (and the Oatley Electronics module) would be

to use the negative supply generator as shown in the "12V metering system using the same battery for meter power" diagram. Then power it from the 5.6V rail of the Spark Energy Meter and apply the voltage from IC3c's output to Vin of the Q2220 LCD module. R_A would be 10kΩ and R_B 470kΩ. This resistive divider reduces IC3c's output voltage by a nominal 48 times.

The calibration trimpot within the module will need to be adjusted to correct for the fact that the R_A and R_B resistive divider only divides by 47.8 rather than 50 and for other resistance tolerances in the Spark Energy Meter, such as the 150Ω 5W resistor. That calibration is as described in the Spark Energy Meter article.

An alternative arrangement that does not require the negative supply may be possible. That would be with J3 open and J1 and J2 closed. You would need to be able to isolate the -In terminal on the Q2220 from the GND (ground) terminal.

Then it would be just a matter of connecting the Common and -Vref, Vin and -In on the Q2220 to the equivalent COM, REL, INHI and INLO as shown for when using the Jaycar module. Note that for the Q2220, R_B would be a wire link and R_A out of circuit.

For the decimal point, the circuit diagram for the Q2220 shows that a decimal point needs to be connected to the inverted backplane that's provided by the collector signal of transistor Q1. The recommended method would be to use another 5V reed relay (the same type as RLY1) with its coil connected in parallel with RLY1. The contacts would then connect across the P1 decimal point jumper connection on the Q2220.

Spark Energy Meter calibration query

I am building the Spark Energy Meter from the February & March 2015 issues. With the Calibrator, I had to change the 220kΩ resistor to 270kΩ so I could adjust the output to 250Hz. It could not go any lower than 260Hz without changing the resistor for whatever reason, possibly something at my end.

I assume when you connect the Calibrator to the Spark Energy Meter for calibrating the LCD to display "100" (mJ), it requires the spark plug be connected? Yes/No?

For some reason the LCD displays around 170 during the calibration procedure (spark plug inserted); possibly I have made a mistake somewhere. I will check the resistors etc. (P, M., via email).

- The spark plug is is not connected to an ignition coil during the calibration procedure. Simply apply the calibrator signal across the 150Ω resistor. If the reading is too high and cannot be adjusted with the LCD trimpot, there is possibly an incorrect resistor value on the PCB.

Note that the spark plug can be connected to the zener diode PCB but it should not be connected to a running ignition coil when calibrating.

Tidal clock project wanted

What about this as a Silicon Chip project – a tide clock that shows high and low tides? There are tide clocks but they are not accurate and need calibrating often. The tide times change frequently.

My idea is that the tide times be obtained from a government server and used to indicate the hours to high and low tides as on a tide clock. Normally the high tide is at the 12 o'clock position and low tide at the 6 o'clock position. Maybe a stepper motor could be used or maybe the minute hand of a quartz crystal clock movement with the stepper motor directly driven by a microcontroller.

Maybe there could be a advanced version that also has a 7-segment display at the 12 o'clock high tide and 6 o'clock low tide position to also show the tide times. I should add that I know about smartphone apps to check the tide but I think a wall clock would be more convenient. (R. W., via email).

- We think it would be a lot of work to program the clock for all available sites in Australia, let alone other countries. And that is without showing the prediction for tide heights.

We recently incorporated world time zones into the Nixie Clock With GPS Time (Silicon Chip, February & March 2015) and that really involved

Alternative Modules For GPS Frequency Reference

I want to build the GPS Frequency Reference (Silicon Chip, February & March 2007) and I want to know if the Garmin GPS unit is still available. If not, are there suitable alternatives please?

Also, what type of 35mm film canister is used for the mini oven. Is it a plastic version of the metal/aluminium type? And is there a reason why no power on/off switch was included with this unit? (P. O., via email).

- As far as we know, Garmin no longer makes the GPS-15L receiver module but we believe Garmin has a replacement module for the GPS-15L called the GPS-15xL. This is a direct replacement but with more sensitivity. Also, both Sparkfun (www.sparkfun.com) and Futurlec (www.futurlec.com) have receiver modules that should be compatible with the GPS Frequency Reference and they are not too high in price.

Futurlec has a MINIGPS module which will operate from either 3.3V or 5V, has an SMA socket which is compatible with an external active antenna and has a 1pps output.

Sparkfun has two possibilities: the Venus GPS Logger, with the Venus-638FLPx receiver inbuilt, again with the ability to provide a 1pps output and to work with an external active antenna. It will apparently work from a 3.5-12V supply.

Secondly, they have the Sparkfun GPS Module with the Trimble Copernicus II SMD receiver mounted on a small DIL PCB module (1.1 x 1.25"). This one seems to have all the necessary outputs and has an SMA socket for an external antenna. However, it will only operate from a 2.7-3.3V power supply, so it would need a small added regulator to work inside the GPS Frequency reference.

The mini crystal oven in the 2007 GPS-based Frequency Reference used a cylindrical plastic film canister.

We did not provide for a power on/off switch on this unit because it was designed to run from an external DC supply and it was envisaged that the unit would be left on for long periods at a time.

Light Dimmer With No Interference Wanted

I live in an area with poor AM radio reception and I find that all normal light dimmers cause major interference when they are in use. Do you have a solution? (M. K., via email).

● As it happens, there are two approaches which may help with your AM reception and its susceptibility to interference. The first is to build or purchase a noise-cancelling loop antenna. These can be very effective in improving AM reception and we have published several designs in the past, as can be found by doing a search for loop antenna on our website. You can see some previews at:
www.siliconchip.com.au/Issue/2009/January/AM+Broadcast+Band+Portable+Loop+Antenna
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However, you may also want to build one or more light dimmers which produce no radio interference. For this you need a non-switching design which does not employ a Triac. For that we would nominate our Deluxe Fan Speed Controller from the May 2014 issue. This is based on a high-voltage Mosfet.

In effect, it can be regarded as a variable resistor in series with the incandescent lamp you want to dim. This means it is much less efficient than a Triac switching dimmer and it has a maximum lamp load of 60W. You can see a 2-page preview at: www.siliconchip.com.au/Issue/2014/May/Deluxe+230VAC+Fan+Speed+Controller

a great deal of programming. We also think that since there are the smartphone apps you mention and easy access to similar information from many websites, most readers interested in the tides would simply go to their computer or smart phone.

For example, in your area you can get relevant tide information from http://tides.willyweather.com.au/vic/mornington-peninsula/earimil-beach-south.html

Defective transformer in Multi-Spark CDI

I ordered the PCB and hard to get components from your site for the Multi-spark CDI (Silicon Chip, December 2014 and January 2015). After I completed the circuit, transformer and everything else according to your explanation, I put the CDI on a bench power supply.

Everything was OK and the voltage level adjusted to 300V. Connected to the car reluctor triggering, I adjusted the sensitivity as described. I started the car and it started right away, with prompt response of the gas pedal and everything. But 10 minutes after the initial fire, the CDI just powered off and it doesn't fire.

I measured everything that can be measured with an instrument, discrete components, transformer etc and everything is OK but the oscillator is not working and there is not 300V on the test point. Can I check the SMD ICs without the use of an oscilloscope because I don't have it?

Something has obviously burned up because the CDI worked for 10 minutes and then it just stopped. And every measurable component is OK, except the ICs which I can't check without the oscilloscope? Any suggestions? (A. F., Skopje, Macedonia).

● The most likely the problem is a breakdown in the transformer secondary winding due to arcing or where there is a large voltage differential between turns on the secondary.

DI box modifications

I built the DI box (Silicon Chip, May 2006) which I have just taken apart to replace a damaged socket. The circuit of the October 2014 project is almost but not quite identical to the May 2006 project.

I note that the unit I built has a 4.7kΩ resistor between the jack tip and the transformer yellow wire but the new version only has resistors on the stereo input and they are 2.2kΩ, not 4.7kΩ. Does the presence or absence of the 4.7kΩ resistor alter the performance? Should I remove the resistor from my box?

I can easily add a 3.5mm stereo socket with two 2.2kΩ resistors to my 2006 box. (G. C., via email).

● The May 2006 DI box had a combined mono and stereo input and required stereo mixing resistors that were included whether using a mono jack or not. For a mono signal, the input signal is reduced to one half its original level at the coupling transformer input.

The October 2014 DI Box has separate mono and stereo inputs and this means that the mono input need not have attenuation resistors but only resistors for the stereo input that acted to mix stereo. Using separate mono and stereo inputs as in the October 2014 DI box can give better a signal-to-noise ratio for the mono input but since the signal-to-noise ratio is below the noise floor of our instruments, the improvement is not measurable.

It would be easy enough to include the stereo socket on the May 2006 DI Box and use the same circuitry as the October 2014 DI Box. The use of 2.2kΩ instead of 4.7kΩ resistors for stereo mixing will not noticeably change the signal-to-noise ratio – it will give a theoretical improvement of almost 1dB, assuming a 10kΩ input impedance for the coupling transformer.

Induction Motor Speed Controller malfunction

I am having problems with the Induction Motor Speed Controller unit when it comes to controlling speed via the external mode for a 240VAC single phase motor. It works with the internal pot but not the external mode. It also all worked on my 3-phase 1.5kW motor when it was first built and it has had all the recommended modifications carried out.

After trying to get it to work on the 240VAC single-phase motor I put it back onto the 3-phase motor and experienced the big bang! On inspection the current shunt resistor was missing. I believed this happened to your original controller (Silicon Chip, April & May 2012) as mentioned in the December 2012 article.

The only thing I had forgotten to

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set were the DIP switches; they were all in the off position. I see that you have some parts that upgrade the controller if it suffers failures. Would my single-phase problems be in the PIC microcontroller's program? (D. H., via email).

● We doubt the software was at fault. If there were still software problems, other constructors would be having similar issues.

We are assuming you were changing the EXT DIP switch setting when changing between the internal and external speed pots. We can only imagine that a hardware fault in one channel such as faulty soldering on the IGBT bridge or one of the SMD capacitors has caused strange behaviour and eventual failure.

We can supply the up-rated IGBT bridge IC (30A/60A) and replacement shunt resistor for $40 + postage. Note though that you may also need to replace IC2 and possibly some of the optocouplers as these may have also

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Next Issue

The July 2015 issue of SILICON CHIP is on sale in Newsagents by Thursday 25th June.

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been damaged. The former is available from Jaycar or Altronics.

If you're going to replace those parts you should inspect all the solder joints carefully, especially the SMD capacitors, to minimise the chance of another failure after doing the repair work.

Headphone amplifier for hearing-impaired

My hearing aids do a reasonable job of improving intelligibility when listening to TV or music via an A/V amplifier and speakers. However, for private listening via headphones, I was wondering if you would consider a project for a small stereo amplifier/equaliser between the headphone socket and 'phones which would have an individually adjustable or programmed boost response to mirror one's hearing loss curves, as programmed into the hearing aids? What do you think? (T. S., Tauranga, NZ).

● What do other readers think of this idea?

LED strobe not bright enough

I was wondering if you could assist me. I have built the LED Strobe project (SILICON CHIP, September 2008), as supplied in kit form by Altronics. However, the LED does not appear to be as bright as other 1W LED lights I use. In fact, it is considerably dimmer.

I have powered the kit from a small 12V sealed lead-acid rechargeable battery (12V 7.0Ah) to make it portable and re-chargeable. I need to use the unit in day conditions (not direct sunlight but still a fair amount of light where I need to work) and at present I am limited to pre-dawn and post sunset operation.

Is there any way to modify it so that I can increase the LED brightness? (C. K., via email).

● The 1W LED is being driven with the correct current, so you may need to use the 3W white version of the Luxeon or Cree LED to get more light. Q1 would need to be replaced with an IRF540 Mosfet with the gate, drain and source in the base, collector and emitter connections for Q1 respectively.

The 220Ω resistors from RB4 and RB5 should be changed to 22Ω. Then the 3W LED can be driven with higher current. This requires that the 39Ω 5W resistor be replaced with two paralleled 22Ω 10W resistors. Additionally, the 1N4004 diode (D1) needs to be a 1N5404 (3A) diode. SC

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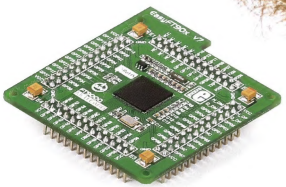

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3 Piece - Sheet Metal Step Drill Set - HSS (D1071)
25 Piece - Precision Jobber Drill Set - HSS (D1272)
9" - Drill Press Locking Clamp (C103)
Standard - Drill Press Vice (H125)

Order code: (D147)

BG-8 INDUSTRIAL BENCH GRINDER

- 200mm wheels
- Fine/coarse grit
- Safety stop switch
- 1hp, 240V motor

Order code: (G161)

PACKAGE INCLUDES:
GSS-200W - Bench Grinder Stand (G152)
LA-362 - Multitool Grinding Attach. (L0865)
Grinding Wheel Dresser (G1894)
915 x 50mm Scotchbelt (A36G50)
Belt Cleaning Stick (G1853)
178mm Velcro Backing Disc (A0700)
ALUMINUM GRIDE
178mm Disc Pack 80G (A6333)
178mm Disc Pack 120G (A6335)
915 x 50mm Belt Pack 80G (A8002)
915 x 50mm Belt Pack 240G (A8005)

$729 SAVE $96.55

BF-16V MINI MILL DRILL

- Electronic variable speed
- Geared & Tilting Head
- Dovetail column
- Head tilts ±90°
- 500W 240V motor
- Travels:
  - (X) 220mm
  - (Y) 160mm
  - (Z) 210mm

$1800 SAVE $249.30

PACKAGE INCLUDES:
ST-1620V - Mill Drill Stand (M651)
3MT x ER32 - Collet & Chuck Set - 8 Piece (C3228)
HF-1/2 - Clamp Kit - 58 piece (C350)
10 Piece Metric - Slot Drill & End Mill Set - HSS (M3301)
VK-4 - K-Type Milling Vice (V104)

Order code: (M649)

AL-51G BENCH LATHE

- 230x500mm turning capacity
- 20mm spindle bore
- Quick change gearbox
- Speeds 100-1800rpm
- 0.55kW, 240V motor

Order code: (L160)

PACKAGE INCLUDES:
ST-51G - Lathe Stand (L203)
5 piece - Lathe Turning Tool Kit - Insert Type (L0055)
Heavy Duty - Drill Chuck - Keyed Type (C238)
2MT x JT6 - Drill Chuck Arbor (D442)
Live Centre (C350)
Fitting and Machining Technical Book (L341)

$1850 SAVE $255.40

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